U. S. NAVAL HARBOR DEFENSE MANUAL

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Naval Harbor Defense Operational Manual

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THE CHIEF OF NAVAL OPERATIONS

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NAVY DEPARTMENT
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON 25, D. C.

1 January 1946

1. The "Naval Harbor Defense Operational Manual" is a restricted publication prepared by the Chief of Naval Operations as a training and informational guide to all naval personnel during the postwar period and as a handbook for assigned naval harbor defense personnel should another emergency be declared.

2. This manual will be kept up to date as much as possible. As new developments in harbor defense equipment, tactics and counter-measures are made, the information will be printed and mailed to all commands which have the publication in their library.

3. Commissioned, warrant and enlisted personnel and all other authorized persons whose duties are either directly or indirectly connected with naval harbor defenses are invited to make recommendations to the Chief of Naval Operations on the improvement of the manual or improvements in the harbor defense program in general. Such recommendations should be forwarded to the Chief of Naval Operations, Op415E3, Navy Department, Washington 25, D. C. Requests for additional copies will be forwarded to the same address.

H. H. Good

H. H. Good,
Rear Admiral, U.S.N.

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NAVAL HARBOR DEFENSE OPERATIONAL MANUAL

INTRODUCTION

The primary purpose of this manual is to furnish information on the subject of harbor defenses to interested United States naval personnel. It can be used as a book to give general information for officers and men who will not be assigned permanently to the harbor defense program, or it can be used to give, through articles printed here and through the bibliographical references which conclude each section, a very thorough understanding of each subject.

The ultimate goal to be reached by the publication of the manual is to have a large percentage of naval personnel familiar with the job of harbor defenses so that they can be qualified for quick assignment to assume the responsibilities of defending a harbor should another emergency be declared.

Naval harbor defenses had no such program at the beginning of World War II. It took steady progress throughout the war to build the program that was in effect when peace was declared and to learn the lessons of installation, operation, and maintenance that went along with each defense.

This manual will also serve as a challenge to naval personnel—a challenge to be prepared at all times to do a very important job in protecting ships and shores, personnel and material, against enemy attack.

After the bullets and shells started flying on 7 December 1941, authorities in both the Army and Navy were all agreed that the armed forces of the United States had their greatest job in history to perform. The strength of the Axis powers showed not only mighty divisions of Army air and ground forces but also huge and powerful forces of naval strength in the Pacific and Italian theatres.

The U. S. Fleet was not so strong in those early days. Pearl Harbor had docked a large portion of the Pacific fleet before war broke out and was to keep a large portion of those ships permanently. Japanese bombers and fighters saw to that.

But the U. S. Navy was far from licked. Armadas of our battleships and cruisers could not be sent to engage the enemy at that time, but planning authorities never doubted that some day they would be there. They foresaw the largest Navy in the history of the world—belonging to the United States. Shipyards began humming at a much more rapid speed. The Navy's personnel began increasing. Training schools began springing up in every section of the country, covering every subject from basic elements of navigation, seamanship and communications to the very detailed study of Japanese, German and Italian languages—so that the Navy would know how to deal with the people when the early defeat at Pearl Harbor developed into an overwhelming victory.

Yes, the Navy expanded fast. Yet, its expansion did not include just the fleet section. Bases had to be developed both in the continental U. S. and in surrounding areas. If the war were to find the Japs back to their own Empire waters and if the German submarine threat in the Atlantic were to be licked, advanced bases had to be planned—ready to move in. In other words, when the plans for ships matured into actual guns, armored steel plates and engines, bases had to be available to accommodate them.

In the over-all planning for continental and advanced bases, a section for harbor defenses was organized. There would be little point in spending huge sums of money and in organizing fleets of war and cargo vessels unless those ships, upon entering a harbor and dropping anchor, could be protected against the enemy's submarines, sneak craft, motor torpedo boats, and war vessels. Harbors would be happy hunting grounds for any enemy commander—unless there was ample harbor defense to combat the obvious threats.

In outlining the harbor defense plan, a joint directive was issued from the War and Navy Departments, designating the responsibilities of each service in giving complete coverage to harbors. Into the Navy's section fell the responsibility of defense in underwater detection, nets and booms and surface detection radar, with the antisubmarine and harbor patrol components added at a later date. The Harbor Entrance Control Post was to be a joint command in every respect, with both Army and Navy watch officers on duty at all times to direct what action that may become necessary from the activities under their control.

Joint Army and Navy harbor defenses were not instigated in all harbors during the war. In some areas the Navy directed all defenses, while in others the Army handled the job. However, in all continental and major advanced base harbors there was seldom a case where the Army and Navy failed to assign all available defenses to the one important mission of protecting the ships and shores inside the entrance from enemy action.

"Naval Harbor Defense Operational Manual" does not cover everything that has been written and recommended concerning harbor defenses. Such an undertaking would mount into volumes. Yet, the editors of the manual feel that by selecting the articles that are published a student of harbor defenses will learn much about the subject. To cover the more detailed subjects that are not published in the manual, students are urged to use the bibliography which is printed with each section. Subjects in the bibliographical references cover all phases of defense, including the highly important and technical details of maintenance which are published only in general terms in the manual.

The manual covers the various subjects as they were known at the end of the war. However, according to present plans, the harbor defense section will not remain as it was when peace was declared. More research in radar, underwater detection, nets and booms, and other harbor defense phases will be conducted to some extent in the post-war period. As this information is made available, it will be printed and sent for inclusion in the manual to all commands which have the publication in their library. It is planned to keep the information as up-to-date as possible.

Holders of the manual are urged to use it to maximum advantage. Harbor defenses were a very sectionalized part of the Navy during most of the war years. When the name "Radio-Sono-Buoy" was mentioned, the most common question that followed was "What's that?" The same question was usually asked when Harbor Entrance Control Post was mentioned only as "H.E.C.P." Close familiarity with the equipment, components and function belonged only to those officers and men who were trained for the work and to research engineers and manufacturers who handled the equipment.

Any suggestions on improvements to the publication are desired by the Chief of Naval Operations. Interested personnel are requested to write to the Chief of Naval Operations, OP415E3, Navy Department, Washington 25, D. C.

CHIEF OF NAVAL OPERATIONS
NAVY DEPARTMENT
Washington, D. C.
1 January 1946

REPORTS LOCATED IN SECTION OP415E3

Office of the Chief of Naval Operations

Throughout the war a large number of reports covering harbor defense installations in every theatre of operations has been received by the Chief of Naval Operations. Some of these reports covered the harbor defense installation in general while others furnished details on individual components.

Very few of these reports received wide distribution. Their contents covered merely one locality or one harbor which was of outstanding importance to CNO but which held no purpose for general distribution.

Students of harbor defenses are invited to use CNO's files at any time should they desire further information on specific harbor defense installations than this manual presents. Pictures, as well as detailed written reports, are available on practically every harbor defense station that was in operation during the war.

These reports, however, cannot leave the Navy Department. Students who desire to study them must discuss with their commanding officer the possibility of getting temporary duty orders to CNO for a limited period during which time the harbor defense section of CNO will offer all possible assistance.

ARMY HARBOR DEFENSES

The contents of this manual outline the responsibilities of naval activities in harbor defenses as approved by the joint chiefs of staff. It will be necessary for a harbor defense student to acquaint himself with the responsibilities allocated to the Army before he can thoroughly understand the overall story of harbor defense.

The War Department Field Manual on "Coast Artillery Tactics" is recommended to all naval personnel for study. "Coast Artillery Tactics" presents a thorough outline of Army harbor defenses and will give a naval student a much broader understanding on how harbor defenses must be a joint operation before they can be considered complete and effective.

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Section I—GENERAL HARBOR DEFENSES

FUTURE HARBOR DEFENSES

Naval harbor defenses are going to find their place in the postwar period along with the many other specialized sections of the Navy. They will not be defending harbors against an enemy as they did during World War II, but personnel will be given training to do such a job in case such a defense is ever needed again.

The following is quoted from a letter by the Chief of Naval Operations to the Bureau of Naval Personnel, recommending a harbor defense school:

"Harbor defense was neglected up until the start of this war, and, as a result, the harbors of the United States and its outlying bases were exposed to the dangers of successful enemy attack to a far greater degree than was necessary or justifiable. During the war, great improvements in the technical aspects and efficiency of harbor defense were made. These improvements were, to a large extent, accomplished by reserve officers, most of whom will soon leave the naval service. Unless positive efforts are made to keep the art of harbor defense alive and progressive within the regular Navy, that art will die as experienced reserve officers return to civilian life.

"The development of new weapons which pack enormous destructive potential into a relatively small space points to the dangers of a major disaster as the result of a single harbor penetration. Future aggressors may be expected to direct initial efforts toward nullifying the Naval strength of the United States by use of new weapons applied by sneak methods against our fleet anchorages. It is the function of harbor defense to detect and frustrate such attacks.

"Harbor defense duties in any future emergency will be assigned to a large extent to reserve officers, as they have been in the past. If this is to be done efficiently, a nucleus of regular Navy personnel, about which a large reserve organization can be created, must be maintained. Organization of a harbor defense school where regular Naval personnel can be trained to form such a nucleus is not intended to earmark such personnel who attend for continued specialization in harbor defenses, but only to insure that the regular Navy will always have a number of officers who have a broad knowledge of harbor defense and who will be capable of training reserve officers in the performance of harbor defense duties.

"The basic principle which must be kept in mind in the establishment of the harbor defense school is that all elements which contribute to the Navy's responsibility for the security of a harbor be closely integrated and that each officer performing any function in harbor defense must have a thorough knowledge and appreciation of the responsibilities and problems of each other harbor defense component. This principle has shown itself essential to efficient harbor defense during the late war. . . ."

The harbor defense school, in following CNO's recommendation, would be of eight weeks duration with six classes being provided each year, covering basic training, Harbor Entrance Control Post, net and booms, fixed underwater detection, surface detection radar, anti-submarine harbor defense patrol and harbor patrol, and minesweeping.

After the harbor defense training school has been organized, all available information concerning research and developments as well as any new policies that have been accepted by CNO will be forwarded immediately for inclusion in the training curriculum.

Harbor defenses during World War II proved to be highly efficient in most harbors. The policy as approved by CNO and which was taught to assigned officer and enlisted personnel in the various training schools allowed the more important Allied medium and major advanced base harbors in every theatre of operations to anchor fleets of cargo and war ships with very little interference from enemy submarine or sneak craft threats.

Yet, no policy is ever so complete and workable that it cannot be improved. Personnel who are in the field and are working with the defenses that they were taught while on continental duty often find themselves in a position where revisions are necessary. In turn, they find that their own method is the best that could be used under the existing circumstances.

Then too, they develop in their own minds through personal experiences with a harbor defense organization what they imagine to be the "ideal harbor defense."

Because of enthusiasm and outstanding initiative in their work, a large number of these officers and men recommended their thoughts on harbor defenses to the Chief of Naval Operations on many occasions during the past war. Many of these suggestions were along the "watch-out-or-this-will-happen" line, while others said, "I believe that harbor defenses can be much more effective if . . ."

By giving careful study to all of these recommendations, CNO managed to improve harbor defenses immeasurably. Not all of them were recommended to units in the field, because their nature was very centralized and not general enough to cover all harbor defenses everywhere. Yet, those that were not used were usually recognized as "good food for thought."

In planning harbor defenses during the post-war period, many recommendations from the field will receive a large amount of study, and some of them may even be the foundation for a new, streamlined program in some harbor defense components.

It would be impossible to include in this limited space the many recommendations that have been received on harbor defenses by CNO. Yet, there is one report which is considered to be highly representative of the thoughts concerning "harbor defenses of the future."

This report was written by an officer attached to the staff of the Service Force, Seventh Fleet, during the latter months of the war after serving with the Harbor Entrance Control Post, Manus.

A large portion of this report follows:

"I wish to recommend the provision in decommissioned status of a certain number of ships intended for use, in event for need, as floating Harbor Entrance Control Posts for advanced bases, together with an appropriate number of related patrol craft and net tenders . . .

"The great advantage of a floating HECP or Harbor Entrance Control Ship for advanced base work as compared with a shore HECP station at a newly occupied or newly established base is that (a) it could set up harbor protective activities immediately upon the occupation of the location instead of having to wait for several critical weeks for construction of a shore station, and (b) if the theatre of operations proves to be a moving one, the harbor entrance ships can be moved along to new locations without the waste involved in abandonment of what may prove to be a short-term establishment. . . .

"Immediately upon the securing of a new harbor desired to be used as a fleet anchorage or base, the Harbor Entrance Control vessel, especially designed, could be dispatched to the spot or could go in with the occupation forces. Accompanied by its own patrols and at the outset by a net tender, it could lay nets to protect the anchorage, lay Sono-Buoys and monitor them, and could operate as a combined examination vessel and HECP in identifying approaching craft, directing patrols and maintaining the usual communications with the shore base or SOPA. . . ."

An experiment was made on the suggestion of a floating HECP or harbor defense ship when the invasion of the Philippines started at Leyte Gulf, but its success was not strong enough to warrant a general change in harbor defense policies elsewhere. In the planning of the Leyte invasion, naval authorities felt that harbor defenses would be one of the most important service assignments after the troops went ashore. The sea lanes for Japanese submarines and sneak craft were reduced considerably and were well within range of the invasion beaches.

To meet this expected threat, a special arrangement was made for harbor defenses. Two net tenders, loaded with sound personnel and equipment, together with one AKN, equipped to install anti-torpedo nets, were assigned to the first reinforcement convoy to enter the invasion area. The original plan called for Sono-Buoys to be installed and in operation by D plus 10; but because of higher priority jobs which were assigned to the net tenders, the actual installation was delayed for approximately two weeks.

Following the installations, the net tenders remained "on the line" as monitoring ships for two months before establishments were completed to the point where the watches could be moved ashore. During this time, the tenders handled all of the maintenance and operations of the Sono-Buoys, worked closely with patrol craft in investigating suspicious contacts, and kept SOPA informed on all matters relating to the security of the harbor.

After sound operations were transferred ashore, one of the tenders was assigned to be the Harbor Entrance Control Post with an anchorage at the mouth of San Pedro Bay. This duty was suspended after other major Philippine invasions were completed and the importance of the base together with convoy traffic was reduced. A shore-based HECP was placed into operation shortly thereafter.

This "floating harbor defense experiment" was considered successful in a temporary status; but in order to place such a plan on a permanent basis, many different arrangements were considered essential, covering such details as housing, messing, recreation, and supply train.

Yet, the plan proved that floating harbor defenses could be very successful, and such a proposal might be a very strong point in harbor defenses for any future emergency.

HARBOR DEFENSE UNIT

In compliance with the recommendation of the Commander-in-Chief, Pacific Ocean Areas, a new harbor defense unit was established in the summer of 1944 which was headed by an experienced and highly trained officer-in-charge. Prior to the execution of an assault, this harbor defense expert could formulate and submit to the prospective base commander a defense plan which provided for the selection of readily handled

equipment to occupy a minimum of space in vessels of the first echelon and which would lend itself to expeditious installation with a minimum of facilities in the accomplishment of adequate harbor protection as soon after D-day as practicable. Heavier defense elements could then be scheduled in later echelons as they were needed for the harbor's protection on a more permanent basis. The "teeth" of the unit was provided in the form of fast and deadly little Coast Guard cutters known significantly as "Subbusters."

The establishment of a unit in which all of the harbor defense components are organized into one big efficient team was considered advisable at the time of establishment because of Pacific bases being within striking distance of Japanese short-range surface and submersible craft, making it mandatory to have the most efficient harbor defenses possible. In anticipation of the establishment of the Harbor Defense Unit, certain officers were earmarked as the best harbor defense officer material available, and the summer of '44 a coordinated team training program for the Harbor Defense Components was put into operation. As a result of this preliminary training, the first Harbor Defense Unit was organized and trained and standing by for orders only six weeks after its establishment was authorized.

The new unit was composed of Harbor Entrance Control Post, harbor detection, surface search radar, net and boom, and the new harbor defense antisubmarine patrol components, all under an officer-in-charge carefully selected for his experience and demonstrated ability.

The officer-in-charge of the unit organized and trained his unit prior to departure from the United States. Upon his arrival overseas, he was well qualified to become the Harbor Defense Officer on the base commander's staff. Officers for this duty were selected with extreme care, with special attention given to their organizing ability, initiative, leadership, and judgment. Normally, they would have had practical experience in setting up and operating defense systems at advanced or continental bases. Therefore, they were qualified by experience and training to make long-range detailed plans, or "on-the-spot" decisions concerning the installation and operation of the equipment in the unit. The logical position for the Harbor Defense Officer in the base commander's organization was that of assistant to the Operations Officer for harbor defense. As such, he could coordinate the efforts of all harbor defense components with those of base defense and other base activities.

The Harbor Entrance Control Post, acting as "nerve center" for the entire harbor defense system, was the military guard post whose primary function was to deny entrance to the harbor of unfriendly ships. It maintained direct operational control of coast artillery, searchlight batteries, controlled mines, net gates, and harbor antisubmarine patrol vessels. HECP officers received specialized instruction in tactics, military liaison, recognition signals, challenge procedure, identification by silhouettes, communications, controlled mines, coast artillery, nets, underwater detection, surface search radar, and harbor patrol as applied to harbor defense. During training all personnel acquired practical experience in the installation, operation, and maintenance of HECP equipment.

The Harbor Underwater Detection Station acted as the "listening post," where a continuous watch was maintained on underwater devices and medium range surface search radar which were able to detect any vessel in the harbor approaches. It obtained, evaluated, and relayed information of a contact to the HECP watch officer for appropriate action. Harbor detection personnel received practical experience which was correlated with technical instruction in the installation, operation, and maintenance of underwater detection equipment, with emphasis on special training in the identification of underwater sounds.

The surface search radar component provided with the harbor defense unit acted as long-range "eyes" to detect surface vessels or low-flying planes well outside the harbor approaches. However, the medium range radar operated from the detection station complemented the underwater detection equipment and confined its search to those parts of the harbor approaches for which the station was responsible.

Personnel of the radar component received technical training and practical experience in the installation, operation, and maintenance of their gear. Special emphasis was placed on the evaluation of contacts and reporting procedure.

In the Harbor Defense Unit the primary functions of the net component was to install, operate, and maintain nets and booms for the protection of ships in the anchorage, and to block unused entrances. Instruction was given net personnel on the tactical use of the various types of nets, seamanship, small boat handling, net tender operation, and the use of ground tackle in net installation.

The Harbor Defense Anti-Submarine Patrol component provided "teeth" for the active defense of the harbor and had as its primary tasks investigation of unidentified ships, investigation of reported contacts by detection devices, and the attack and destruction of unfriendly craft attempting to penetrate the harbor defenses. The standard patrol component included three 83-foot Coast Guard cutters—lethal, seaworthy little craft capable of 18-20 knots. Special provisions were made to keep the main engines warm even when they were stopped, so that under any circumstances maximum

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speed could be attained within five minutes. This meant that a patrol boat in an area with a five-mile front could reach any position in the area within 12 minutes. These 'Subbusters" were equipped with echo-ranging gear, SF radar, two searchlights, mousetraps, depth charges on stern racks, and a 20-mm. gun. Each boat had a crew of one officer and 13 men. The size, speed, and armament of the "Subbuster" was admirably suited to harbor anti-submarine patrol, but its range, while great enough for harbor work, was inadequate for escort duties at sea.

The entire Harbor Defense Unit was assembled and given coordinated team-training in the United States. During this training the officer-in-charge supervised the assembly and disposition of personnel and material composing the several components so that everyone acquired practical experience in installing, operating, and maintaining the equipment of his own components under simulated advanced base conditions, in addition to learning the functions of all other components and how they were performed. At the end of this program every officer and man in the Defense Unit clearly understood his own job and its relation to the mission of the entire Unit.

COMPONENT TRAINING

This new type of training was initiated to answer the need in the field for better coordinated harbor defense. Formerly, a good many of the component units of harbor defense were sent into the field without an opportunity to learn how they were supposed to work together as teams. This system resulted in considerable confusion during the initial phases of base establishment; it is parallel to the situation that would result if a ship of the line were sent to join the fleet without a shake-down first.

It is the function of the training base to simulate as nearly as practicable all conditions encountered overseas incidental to installing harbor defense equipment as well as presenting the units with the opportunity of establishing an "espirit de corps" while operating as organized teams. Laboratories, classrooms and harbor facilities were made available to offer every opportunity to promote the organization of men and coordination of activities for the units.

Component training at San Pedro, California, involved Harbor Entrance Control Post, Harbor Patrol, Surface Search Radar, Net Defense, and Harbor Detection. Each component was given a number and was dealt with as an individual unit under its own officer-in-charge, who organized his unit, chose his leading Petty Officers, and found out the capabilities of his men. He had opportunity to drill them in the installation and operation of every type of equipment.

The next step in the training program was to acquaint the officers and men of each component with the mission and responsibilities of other components. This was accomplished by lectures, visual aids, observation trips, and, where applicable, by letting the members of one component actually operate the gear of another. Sanitation, housing, messing, and base facilities in general were covered by lectures and visual aids. Helpful hints were given in first aid, malaria control, and jungle life.

In the next phase of the training, officers in charge of the various units were given a problem in harbor defense which they were to solve jointly. The solution of such a problem on a joint basis demanded that all officers have a good understanding of not only their own problems but those of the other components in the harbor defense organization so that coordinated plans could be made which would not only allow each component to do its own work with the greatest efficiency but to help rather than interfere with other units.

After the planning was accomplished and settled to everyone's satisfaction, a site was chosen and marked off to simulate the hypothetical harbor for which the planning had been made. The various components then actually carried out an installation as far as equipment available would allow. After the installation was made, they would operate for a short period of time and then would be disestablished.

In the last stage of the training, men and officers became intimately acquainted with the problems of packing and unpacking, transportation, camp site selection, installation site selection, and with multiple other problems which ordinarily are impossible to predict.

At the same time the component training was going on, specialized classes in electronics, A to N, marlinespike seamanship, piloting, boat handling, cable laying, physical education, communications, etc., would be proceeding.

At the end of the course, officers-in-charge would have had an excellent opportunity to work closely with the men in their respective units and were prepared to suggest reassignment of individuals in order to obtain maximum personnel efficiency. Officers themselves were screened by staff training officers and, where necessary, reassignments or even deletions were made so that when a component had finished all phases of team training it was at its maximum efficiency and ready to go overseas.

EFFECTIVE HARBOR DEFENSES REQUIRE CAREFUL PLANNING

During wartime, enemy attacks on combatant and supply ships may be expected to be launched from the sea as well as from the air. Air attacks, because of the speeds involved, cannot be repulsed readily from the confines of a harbor; therefore, defense against enemy aircraft will not be considered in this article. The methods which have been developed for use in harbor defense depend on the supposition that the attack will be launched by sea.

Several types of sea attack have been developed, and countermeasures have been devised to meet their threat. The development of harbor defense as a tactical science has been both steady and positive, and at the present time has reached a high state of perfection. The modern harbor defense officer can estimate the value of his defenses to a great degree of accuracy and has means to improve them should insufficient harbor security be indicated.

The scope of duties performed by a trained harbor defense officer may be roughly broken down into four categories: planning, establishment, operation, and maintenance. The last two occur concurrently, but follow the first two chronologically. An intimate knowledge of all four phases is required for the efficient development of each. This is particularly true of the planning phase.

The application of harbor defense tactical education to practice requires a thorough knowledge of the relationship between the technical characteristics of the equipment and the limiting factors introduced by the sites. The procedures for utilizing all available information in making original plans for a harbor defense system requires consideration of many factors not normally associated with harbor defense operations. These may be roughly divided into two categories:

1. Those relating to the mission of the proposed advanced base, such as the number and types of ships to be accommodated, extent of shore-based maintenance and storage facilities, size of staging area.
2. Those relating to the natural characteristics, such as geography, topography and hydrography.

Normally, the harbor defense officer will be consulted in selection of a suitable harbor, thereby precluding the possibility of selecting an anchorage which cannot be adequately defended. The harbor defense officer should prepare data on all possible anchorages in the general area of the proposed base, make tentative plans for their defense, indicating the number and types of ships which can be accommodated. These plans should then be taken to a conference of representatives from all base activities to determine which harbor or harbors would best suit their requirements.

In order to accomplish its mission, the base will require an appropriate amount of flat-land area as well as an anchorage area of sufficient extent to accommodate the number of ships which the base will service. If either one or both of these requirements cannot be met by one harbor, two or more harbors will be required. One harbor may be used as a fleet anchorage with limited shore facilities and another as a cargo port with extensive dock and storage facilities. After the harbor defense officer has had his plans approved for areas on which is built his shore establishments, he should complete detailed plans for the anchorage and its defenses.

Before laying out the anchorage, it will be necessary to determine how many ships of various types are to use the harbor simultaneously. The size and shape of the anchorage area will depend upon the depth of the water, currents, size of the dock area, and the number of berths required for various types of vessels. Circles of the appropriate radius should be drawn to scale on the chart tangential to each other and representing the scope of the vessels at anchor. Circles of 400 yards diameter should be drawn for all except carriers, cruisers, and battleships. Anchorage for cargo vessels should be provided near the docks, and those for large fleet units should be located in accordance with existing tactical plans for the fleet. The present procedure is to represent battleship and aircraft carrier moorings by circles of 1,000 yards; cruisers, 600 yards; destroyers and all other ships by 400 yards in diameter.

These mooring circles should be disposed in the anchorage to give the greatest tactical advantage in event of an enemy attack on the anchored fleet. Normally, battleships and aircraft carriers should be located along the center line of the anchorage inboard of lighter vessels. Destroyers should be anchored to form a screen for the larger vessels and to facilitate their getting underway, especially when the lighter vessels are on daily routine patrol and the heavier ones seldom put to sea. The anchorage should be laid out so as to permit sufficient flexibility in the disposition of the anchored fleet and to enable SOPA to adjust the location of ships at anchor to meet changing strategical conditions. Clearance should be provided between ships at anchor, enabling safe passage of vessels through the anchorage.

The harbor defense officer is usually faced with the necessity of a fair compromise between his requirements for a perfect harbor defense and that which is feasible under prevailing shipping conditions, considering the calculated risk of enemy attack. Tailored components, such as harbor detection units, should not be reduced to the point where their efficiency is impaired, either in number of types of equipment or in the number of watchstanders available to man it.

In order to make maximum use of available shipping

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space, the harbor defense units should be carefully echeloned. If there were no limitations on the amount of shipping space which could be devoted to the various types of base equipment, there would still exist a critical condition governed primarily by the unloading facilities at the newly occupied base. At first, fighting equipment must take priority to insure the successful capture of the base with minimum losses. This includes the necessary supplies required to keep the fighting equipment operating and those required to keep the fighting men healthy and alert. Logically, at approximately this same time, certain light-weight and easily installed harbor defense equipment would insure a certain measure of security to ships bringing in the supplies and fighting equipment as well as augmenting the security of combatant vessels supporting the landing operations and the armed forces on the base.

The need for better harbor defenses at the newly occupied base earlier in the combat operations is very urgent. The time required to capture and equip a new base is becoming more predictable. Since these timetables are so accurately determinable, it also requires that the echeloning of the components which go to make up the base facilities be accurately determinable. This reflects in the care with which the initial plans are prepared and results in the harbor defense officer being more carefully consulted during their preparation. This gives him an excellent opportunity to provide harbor defense facilities in accordance with his ideas of a suitable installation. It furthermore requires of him accurate decisions based upon his experience and eliminates the previous system of planning which resulted in harbor defense units being placed in operating condition months after the time when defenses were critically needed. It places on the harbor defense officer a much greater responsibility and requires of him a much higher degree of training and experience.

The plans for establishing a new advanced base will include echeloning of the material and personnel. The harbor defense officer should complete his harbor defense plans, make up a list of material required in each echelon, break-down this list into functional components, including personnel, and have these components included in the echelon shipment schedule of the base assembly. The Advance Base Initial Outfitting List should be used in setting up the components to standardize the nomenclature.

The harbor defense officer should realize that local conditions at the proposed base may require some modification in the plans as made before invasion. However, for logistic purposes these plans are satisfactory, experience proving that components assembled on this basis have had enough equipment and personnel. The latest available charts of the new base should be obtained and whenever possible corrected from air reconnaissance photographs. Harbor defenses should be drawn on one of these charts.

The anchorage area should first be laid out in the manner previously described, since this will determine, in general, the location of the antitorpedo nets and net gates. The net officer should be consulted in the selection of the best location for the nets since the successful installation and maintenance of a good net line is the result of careful planning based upon experience. In addition to selecting the location of the net in the most favorable water, the net officer will design net defenses, provide the bill of material and indicate what equipment and camp facilities will be required for its installation and maintenance.

The area to seaward of the net line will be used to prevent enemy vessels from getting close enough to the net line to destroy this important anchorage protection, to fire torpedoes or to pass through an open gate. Since effective torpedo range is approximately 10,000 yards, the outer limit of the defense area should extend at least 5 miles to seaward of the net line. If this is not possible, the defense area should be compressed enough to intensify the counteroffensive in proportion to the reduced length of the time allowable for effective defense. This compression will require more anti-submarine patrol vessels, more picket boats and much greater alertness from all harbor defense operational units. It may require a baffle arrangement in conjunction with the gate, or a double net line to insure the anchorage immunity against torpedo fire from seaward.

The area immediately outside the net line should be reserved for special small object and sneak craft detectors and for the net line picket boat patrol. Sneak craft detectors are designed to indicate the presence of small objects, thus enabling the net line picket boat patrol to carry out an effective counterassault. Without the sneak craft detectors, enough picket boats would be required on the net line patrol to keep every 500 yards of net under practically constant vigilance. This would require a considerable number of picket boats, and their effectiveness would not be very great during darkness. Underwater sneak craft detectors properly installed on the inner detection line not only reduce the number of picket boats required on the net patrol but also are capable of indicating the presence of underwater objects which would be beyond the capabilties of the picket boat crews.

The reduction in the number of picket boats also improves the chances for the sneak craft surface detection radar to pick up small floating objects on the surface, since the number of shadows and fixed echoes on the radar screen would be reduced accordingly. When an appropriate amount of equipment is installed on the inner detection line, picket boats can be secured on slip moorings, thereby reducing fatigue of the crews and

the required amount of boat maintenance. The number of picket boats required per mile of net depends to a considerable extent upon the amount of warning time given by the inner detection line. At least one picket boat should be able to reach any point in the inner detection line during the time a sneak craft would require to pass through the positive detection area; otherwise, the picket boat would be required to spread its hand grenades and gunfire over a wide area and would be unable to concentrate its assault within lethal range of the target.

The time required for a sneak craft to pass through the positive detection area depends upon its course, speed, and the thickness of the detection line. The area covered by surface small object detection radar equipment can generally be considered great enough to include all of the inner detection area and usually a considerable distance to seaward of the inner underwater detection line. Radar can be depended upon to pick up floating objects when they are large enough not to be masked in the prevailing sea. Its dependability is approximately that of an alert observer with binoculars under the best of conditions.

Small object underwater detectors normally will be the limiting factor which determines the thickness of the inner detection area. The presently accepted practice is to use a system of very sensitive Magnetic Indicator Loops or an U.E.P. string to initially detect the presence of an incoming sneak craft. This is backed up by a special arrangement of underwater echo-ranging equipment.

The Magnetic Loops alert the picket boats if the target contains magnetic material, whereas the echo-ranging gear shows the exact location of the target, thus enabling the picket boats to concentrate on their assault. In event the target does not contain magnetic material, the Loops will not detect its presence.

However, the early warning given coupled with the probability that the target will contain iron or steel justifies the Loop installations and usually provides information of importance in evaluating the target contact. Inner detection Loops should be installed in water not deeped than 10 fathoms, and the system should be composed of Loops with not over 2,000 front yards in length. Loops on the beach ends of the system are kept in motion by the surf and consequently cannnot be operated at as high a sensitivity as those in deeper water. Beach-end Loops should be considerably shorter than those in the middle to reduce the amount of cable which can be set in motion by the surf. This allows higher operating sensitivity. Loops crossing the channel where high sensitivity is required should not be extended to the beach, because the surf action will lower the over-all operating sensitivity, including that portion which crosses the channel. U.E.P. strings are not as sensitive as the Magnetic Indicator Loops but are more easily installed. They are particularly desirable when installed near the net gate with the indicating instruments on the net gate vessel.

The inner detection echo-ranging line should be composed of Short Pulse Heralds properly spaced along the front approximately 500 yards inboard of the inner detection Magnetic Loop. Since the effective range of these Heralds is limited to approximately 600 yards, they should be spaced not in excess of 1,000 yards to give a 600-yard overlap of the ranging circles. These Heralds may be operated either by using a continuous sweep and observing the target on a plan position indicator, or a fixed beam observing the target on a recorder.

When fixed targets are small in number, the sweep method normally should be used. This gives a thicker effective detection area, the target shows up in relative position on the scope and the recorder shows a blank except when the projector is trained on the target. The fixed beam method is valuable in narrow passages especially when there are a large number of fixed targets, and discrimination is possible only by change in ranges as indicated on the recorder. The thickness of the detection area will not be much in excess of 125 yards when the fixed beam system is used, and Heralds should be spaced not over 900 yards apart along the detection front. The beams should be fixed at a 45° angle with the detection line to give the maximum rate of range change when a target approaches the detection line. If the net line is of considerable length, the inner detection line will require a considerable number of Heralds. It may not always be practicable to carry the inner detection line the entire length of the net because of the number of Heralds required. When this is true and the calculated risk of enemy sneak craft penetration permits, the plans often call for a Herald on each side of the net gates to indicate the presence of anything passing through the gate. This does not provide means of detecting sneak craft approaching the bulk of the net line and does require a stronger patrol to intercept enemy attempts at penetration under the net, through the panels, or over the net jackstay.

When the inner detection line is composed of a complete system of Short Pulse Heralds operating on the sweep system, one picket boat per mile of net should be provided. When the fixed beam system is used in operating the Heralds, one picket boat should be provided for every 900 yards of net line to compensate for the shorter time required for a sneak craft to pass through the detection line.

The inner detection line is primarily designed to indicate the presence of small slow-moving bodies which cannot be otherwise detected. Its location favors high sensitivity in the instruments because of shallow water; and since the location near the nets usually is the narrowest part of the harbor entrance, conservation of

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equipment results. An equally sensitive detection system might be placed on the outboard extremes of the defended area if the water is sufficiently shallow, but usually at this point the defense front is longer and considerably more equipment would be required. The planning officer should decide on the merits of each case—how to use his equipment in the most economical and effective manner.

The warning time given by the inner detection system is not long enough to allow effective assault on larger and faster enemy vessels which also have more striking power and should be kept from reaching the vicinity of the net line. The outer detection system is devised to indicate the presence of large bodies at the outer approaches to the harbor, preferably at least five miles from the anchorage. A complete underwater detection installation consisting of Magnetic Loops, Hydrophones, and Heralds and a surface detection radar will detect the presence of any object as large as a midget submarine. The effective operation of this detection equipment is limited to water not in excess of 60 fathoms, and this technical limitation may preclude the possibility of locating the outer detection line as far to seaward as would otherwise be desirable and may even put an undesirable limitation on the thickness of the defensive area at the entrance to the harbor. If the distance along the channel between the nets and a line tangential to the shoreline outside of the harbor is equal to or greater than five miles, a normal and very effective harbor defense system can be installed, providing technical qualifications such as depth and topography are favorable. If, as at the entrance to a coral atoll, the passage is short and the water outside very deep, a modification will be necessary in the normal detection plan, and artificial means should be used to increase the search area between the detection line and the anchorage. The detection line can be extended to seaward by using Heralds on either side of the passage, so located that the normal range circles overlap, forming a solid outer detection area for 2,000 yards to seaward and around the seaward sides of the passage. The inner detection line should back up this outer Herald detection line, and the space between may be occupied by a Hydrophone line to advantage. Since the thickness of the defense area is so thin, all harbor defense operations must be designed to function with the maximum efficiency and speed.

Regardless of the shape and size of the defended harbor approach, the principles of defense are built on the same general lines as those outlined for the inner detection defense. Detection equipment is used to reduce the number of patrol vessels required and does the job better and more completely than could be accomplished by patrol vessels alone.

Patrol vessels are used to supply the counteroffensive action without which the harbor would not be defended. Patrol vessels equipped with underwater echo-ranging gear and radar and antisubmarine armament should be stationed on slip moorings about 2,000 yards inside of the detection area. A sufficient number of patrol vessels should be provided to bring any point of the detection area and the hunting area under assault within the time required for an enemy target to pass through the detection line. In making a determination of the location and number of patrol vessels, the thickness of the Magnetic Indicator Loop detection area (600 yards) and the Hydrophone detection area (600 yards) should not be combined because of the possibility that only one of these methods of detection will develop on a particular target.

A submarine running at its quietest speed would normally be detected on the Magnetic Loop, but there is a 50 percent chance that it would not be heard on the Hydrophones. A submarine might drift across the Loops and mask its signature in a changing earth's magnetic field, yet be detected by the Hydrophones when it adjusted its trim or operated its diving planes or its rudder. The time required to drift across the Loop and not show a signature would be so great that during that period it would be compelled to use its ballast tanks or possibly even its screws. During the most clever evasive maneuver over the Loops, the fluxmeter would be affected enough to at least raise suspicion in the detection station, resulting in unusual vigilance. An investigating patrol vessel would be disconcerting to the submarine personnel even if it did not result in a positive contact by the patrol vessel. A submarine in suspended drifting condition would be easy prey for an alert patrol vessel, and the investigation might result in the submarine increasing its submergence or speed. In either case, the Hydrophones would pick up the resulting sounds, and the Loop would show a positive indication of its presence. Consequently, a good factor of safety results when only one of these detection areas is considered. However, the thickness of the Herald detection area can be added either to the Loop or the Hydrophone area in determining the number of patrol vessels required.

In calculations for planning purposes, the normal range of the Herald is taken as 2,000 yards. A line of Heralds across the harbor entrance spaced 3,600 yards apart will have a detection area 1,600 yards thick. If a thicker area is desired in order to reduce the number of patrol vessels, spacing between Heralds can be reduced. Heralds spaced 2,800 yards apart give the optimum thickness of 2,800 yards to the detection area. Usually, the 3,600-yard spacing will give a detection area thick enough for all practical purposes when added to that of the Loop or Hydrophone area. Assuming a detection area 1,600 yards thick and an average enemy target speed of six knots and a patrol vessel speed of 15 knots, a

patrol vessel slip moored on the center line of its patrol area 1,200 yards inboard of the outer boundary of the Herald detection area can effectively cover a patrol front of 7,800 yards. If the detection area is only 600 yards thick, the patrol vessel could cover a 2,000-yard front, other conditions remaining the same. Therefore, the number of patrol vessels required is roughly, inversely proportioned to the thickness of the fixed underwater detection area.

The estimates given assume top efficiency in the harbor detection system and rapid accurate control of harbor defense operations. The attainment of high detection efficiency is not within the scope of the planning officer so much as it is a technical matter with the harbor detection officer. The planning officer can, however, improve the conditions under which detection equipment must work by careful selection of the detection area. Likewise, the planning officer can give every opportunity for efficient control of the harbor defense system by selection of a good site for the Harbor Entrance Control Post. The HECP should be in visible range of the harbor approach, the outer detection area and the anti-submarine patrol area. It is desirable that it have visibility over the inner detection area, the inner patrol area and the net line. The best location for the HECP will usually be as near the entrance to seaward as possible. The site should be high enough to give maximum angle of visual observation consistent with ample visibility of the shore line. Adequate telephone facilities should be included in the plans to provide secure lines from the HECP to the net gate vessel, the underwater detection station, the surface detection station, the base operations office, the Army coast artillery and searchlight battery, and SOPA. Visual communication facilities should be provided for signaling to patrol vessels, and ships transiting the approach channel, and a large signal searchlight should be included in the plans for challenging vessels approaching while still far to seaward.

Width of patrol front

can be calculated from following formula:

$$F = 1.4 \frac{Sp}{St} D$$

F = Width of patrol front in yards.
Sp = Speed of Patrol Craft.
St = Speed of Target Craft.
D = Thickness of Detection Area in Yards.

This is based on the Patrol Craft being slip moored on the center line of the patrol area at a point where the patrol range lines to the outer extremes of the detection area meet at right angles.

Location of PC mooring

can be determined from following:

Locate PC mooring on a line running at right angles to the outer boundary of the detection area at its center. The mooring should be located along this line a distance from the outer boundary equal to half the width of the patrol front.

HARBOR DEFENSE TACTICS

The complete defense of a harbor against an enemy requires an almost fool-proof protective system. The importance of safe anchorages within convenient distance of fleet operating areas is apparent, and if all anchorages were of exactly the same size, shape and depth a standard plan for the protection of ships in them could be worked out and applied in all cases. Such a plan would lend itself to improvement and refinement to the point where perfect safety against any type of attack is guaranteed.

But this is not the case. Every harbor presents its own set of problems for the defense activities to study and solve as best they can. It is not practicable to make a study of each harbor captured and then design, manufacture and ship the equipment best for its defense. Nor is it practical to train teams to operate equipment which would be different for each harbor. Such a system would involve unacceptable delay in sorely needed defense installations.

No—from the practical and tactical standpoints some standardization of equipment, training and installation must be established—a compromise between the ideal of perfect standardization and none at all. Still, it is absolutely necessary to devise some way to effectively defend an anchorage against any form of attack the enemy may use, and in World War II some novel and disconcertingly successful forms were used against us. Consequently, protection of our anchorages against various sea-borne Japanese sneak weapons continued to be of prime importance, and this in all conditions of weather and light, depth and topography.

Let us go back to the days before the war ended and see how the problem presented itself.

In approaching such a problem, it is important to know as much as possible about the enemy's methods and capabilities so that not only specific countermeasures can be applied, but provisions made to combat any tactics or new weapons he is likely to use. First of all, sea-borne attack can be pressed either on the surface or beneath it by a variety of craft ranging from heavily

armed surface vessels to an individual swimmer. Methods can range all the way from mass attack by daylight with no attempt at deception, to subtle sneak tactics with very small submersibles which take every precaution to avoid discovery until their lethal work is done and escape assured. To make any defense system confronted with so many potentialities effective is no easy task, particularly when it must be installed and maintained often under adverse conditions. The science of harbor defense has developed to the point where today the anchorage protected by those means described later in this article suffers little risk of successful enemy penetration from the sea.

Fundamentally, the defense of a harbor depends on the early detection, location and identification of any vessel which approaches to within striking distance. Once this is accomplished, powerful counter-forces can be brought to bear in short order. The Navy's harbor defense equipment is flexible enough to be employed in any harbor suitable for a fleet anchorage—and still afford a degree of effectiveness commensurate with acceptable calculated risk.

In planning a harbor defense, every consideration must be given to installing a system which will insure—first, the detection of a vessel before it reaches striking range of the anchorage, and, second, its destruction before it can take any offensive action. Fixed underwater detection devices, surface detection radar and visual inspection are used to accomplish the first of these; whereas, coast artillery, patrol craft and mines are used to accomplish the second.

Surface search radar in the vicinity of the harbor entrance will give the earliest warning of any vessel approaching on the surface and will do so at ranges considerably in excess of those possible by fixed underwater detection devices. Naturally, it would be desirable to plan underwater detection equipment many miles to seaward of the harbor entrance, but usually the technical limitations of the equipment prevent it. However, the underwater detection system should, whenever possible, be placed far enough out so that a submarine must pass through it to get within torpedo range of the anchorage. Quite often this arrangement is very difficult to realize because Magnetic Indicator Loops are not effective in very deep water. In this case Sono-Radio-Buoys can be used since depth does not decrease their effectiveness.

Sometimes the frontal distance to be covered is so great that the amount of equipment necessary to put in an effective underwater detection screen is prohibitive. Usually in a case of this type, it will be necessary to move the detection area shoreward until a point is reached at which the frontal distance is not too great nor the water too deep. Obviously, there will be occasions in planning when a compromise will be necessary in the selection of the exact position to install various devices.

Normally, Magnetic Indicator Loops are laid farthest to seaward because they are the most positive and depend least on the human element for their warning efficiency. Magnetic Loops will give warning when a vessel constructed of magnetic material crosses them, but they give no exact indication of the entering vessel's size, speed and location. This is not enough information. Because some means must be provided for learning more, Cable-Connected Hydrophones or Sono-Radio-Buoys are placed inboard of the Loops. These listening devices give information from which an entering vessel's type, speed and approximate location can be estimated. The accuracy of an estimation made from listening devices depends entirely on the skill and experience of those operating them. Even more information on the entering vessel is necessary for the execution of a successful counter offensive, so Heralds are planted inboard of the listening devices in positions which permit them to echo range on any point in the sonic detection line. When a contact is made by the listening devices, echo-ranging gear is directed towards the vicinity of the contact until it too picks up the target. When this has been done, precise information on the target's speed and course is available in the shore station, and patrol craft can be directed to the exact location of the target.

The shore station from which the underwater detection equipment is manned must be located to afford visual and radar scanning of the detection area. Weather and light permitting, visual inspection will determine whether or not a contact is submerged. Radar will accomplish the same thing under any conditions of visibility. Thus, by strategically inter-relating the location of long-range surface search radar and underwater detection equipment, complemented by short range surface detection radar, a detection network is established which insures discovery of a vessel before it can reach striking range of the anchorage.

The destruction of an unfriendly surface vessel approaching the harbor is the business of the Army Coast Artillery. Usually, submerged targets are the exclusive business of the harbor defense anti-submarine patrol. This is composed of small, fast and heavily armed cutters which are equipped with surface search radar and echo-ranging gear. These vessels are slip-moored in pre-selected positions across the harbor entrance and can reach any designated point in the detection area in 12 minutes.

For tactical purposes the harbor approach, entrance, and anchorage are divided into five areas: the approach area, the outer detection area, the hunting area, the inner detection area, and the anchorage area.

Approach Area.—Primarily, the approach area is of

interest to the harbor defense group because it is here that inbound vessels first come under the operational control of the HECP. Surface detection radar provides continuous search and tracking information of this area so that, if necessary, HECP can give maneuvering instructions to keep vessels clear of a danger zone—even to sending them back to sea. Inbound ships are required to identify themselves before they reach a position from which torpedoes can be fired at the harbor entrance, or the entrance blocked by mining or scuttling. Since harbor bound traffic converges in the approach area, many targets are offered to a submarine lurking nearby. For this reason, base commanders keep 24-hour surface patrols and daylight air patrols in the area.

Outer Detection Area.—Any vessel which may have slipped through the approach area bent on penetrating into the harbor proper encounters its first real difficulty in the outer detection area. Every part of the harbor entrance is guarded by underwater detection devices complemented by adjunct radar. The station which mans the underwater detection gear and adjunct radar reports any contact to HECP where schedules of inbound and outbound traffic are known. Any contact which is invisible or unscheduled is considered suspicious, and HECP orders the patrol to investigate. Undersea craft, the size of a midget submarine or larger, have little or no chance to pass undiscovered through the outer detection area of a modern defended harbor.

In planning the outer detection area, four factors are of major importance—a detection line which cannot be circumnavigated; employment of the various devices to allow maximum effectiveness from the technical standpoint; installation of the devices in the axis of the entrance for a distance adequate to allow target tracking; and the location of the underwater detection station to permit visual and radar scanning of the outer detection area. It is quite true that Magnetic Indicator Loops will give no indication of the presence of a nonmagnetic target any more than the listening devices will indicate the presence of a silent target. However, very few submerged targets are small enough to escape the attention of the Heralds. For that matter there are no mechanically propelled targets which do not possess magnetic and sonic characteristics of some degree. The Magnetic Indicator Loop as normally installed, is improved to the point where midget submarines as small as the German Biber or Seehund will give a positive indication every time. Furthermore, if these craft are underway, they can usually be heard by listening devices at ranges of 500 yards or more. The Herald has little or no trouble maintaining contact with a submereged target of this size within its normal operating range.

Hunting area.—Upon receipt of the first contact report from the underwater detection station, the officer watch in the HECP alerts coastal artillery, search lights, net-gate vessels, and the harbor antisubmarine patrol. A few moments later when more information has come in from the detection station and the HECP watch feels sure that a suspicious contact has been made, the harbor antisubmarine patrol is ordered to get underway and proceed to the indicated area. The net gate is ordered closed. The harbor patrol at the net line and in the anchorage is ordered to stand by. A warning is sent to base operations, and the entire harbor is alerted.

Back of the harbor detection area lies the hunting area. It is here that most contacts by detection equipment are investigated and, if necessary, developed by the harbor anti-submarine patrol. In this particular operation, the HECP performs a function which is roughly comparable to that of C.I.C. The patrol craft are tracked by radar and their position plotted against that of the enemy contact which is being maintained by the underwater detection equipment. If necessary, HECP coaches the patrol to an intercepting course with the target or until such time as echo-ranging contact is obtained by the patrol craft itself. If the target surfaces, it will be detected immediately by both shore-based radar and radar aboard the patrol craft.

The entire operation is under the direct control and supervision of the Harbor Entrance Control Post. Any friendly vessels in the vicinity may be ordered to stand clear for their own protection. The area can be illuminated by the shore-based search lights as well as search lights aboard the patrol craft.

If controlled mines are employed at the harbor, they will normally be planted somewhere in the hunting area since it is desirable that an unfriendly vessel be sunk here rather than further into the harbor where the channel is more restricted and the possibility of blockading exists.

Inner Detection Area—The Germans and the Japanese were quite ingenious and aggressive in their development and utilization of what are commonly termed "sneak craft." Some of the smaller types of sneak craft present a difficult detection problem, and, therefore, special provisions are necessary to defend a harbor against them. These provisions are made in the inner detection area where a recently developed echo-ranging device, known as the Short-Pulse Herald, is used for underwater detection purposes. This device is so sensitive that it will give positive indications on a target as small as a 32-inch mine case at a range of 600 yards. One of these devices gave a good indication of an explosive motorboat proceeding at very slow speed. It gives an even better indication of a high-speed craft.

Scanning the surface of the inner detection area is the SO–12 radar which is so sensitive that it has been known to detect a man swimming on the surface. These two devices constitute the Navy's latest answer to the

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swimmer and human torpedo threat against our harbors.

Since the outer detection area usually lies in considerably deeper water than the inner detection area, a detection device in it cannot be relied upon to detect the very small types of targets mentioned above. It is for this reason that the inner detection area is necessary.

Anchorage Area—The Japanese utilized swimmers and, in some cases, small sneak craft which were launched from an unoccupied portion of the anchorage shore line of harbor newly captured by American forces. In addition to this, the Japanese used overland infiltration as a means of getting swimming saboteurs, floating mines, miniature boats, or sneak craft into the anchorage area.

To combat these tactics, a harbor patrol is established to keep close watch on the anchorage, shore and net lines. These picket boats are capable of 20 knots and carry heavy armament for their size. They are equipped with search lights and small hand-thrown depth charges which enable them to investigate suspicious activity in the anchorage, and, if necessary, deal with any of the above-mentioned sneak methods effectively. These craft are in radio communication with the Harbor Entrance Control Post which can direct their movements and their disposition. They are fitted with smoke pots aft and, on occasion, will act as smoke pickets.

Part of this same patrol is assigned duty adjacent to the inner detection area where the HECP can use them for counter-action or investigation of any contacts made by the detection equipment there.

SELECTION OF STATION SITES

Strategically, it is desirable for the various harbor defense shore stations to be so located that all visually command as many of the tactical areas as possible. Usually local topography does not permit such an ideal arrangement. However, under any circumstances the surface detection radar station must be located so that it can scan all of the approach area and as far beyond as possible. The underwater detection station must afford a view of the outer detection area with as much of the hunting area in sight as possible. The HECP must visually command the hunting, outer detection, and approach areas. Where it is not physically possible for the HECP to visually command these areas, auxiliary stations for the purpose should be erected. The inner detection station must overlook the inner detection area and be sited with consideration for the limitations imposed by the ultra-sensitive equipment.

FIGHTER DIRECTOR PRINCIPLES APPLIED TO HARBOR DEFENSE

The principles as developed for successful fighter direction may prove valuable as a means to improve the chances of a quick interception between harbor patrol vessels and an enemy submarine. In its application to harbor defense, the enemy is tracked by a shore-controlled direction underwater echo-ranging device (Herald) and the patrol vessels by a shore-based directional radio echo-ranging device (Radar). At the shore station the tracks of the submarine and the patrol vessels are plotted on an intercept board based on a large scale chart of the hunting area. The patrol vessels are directed to the interception and set the depth charges by instructions sent by radio.

There are several reasons why directed interceptions may be expected to improve the efficiency of antisubmarine operations in harbor defense patrol areas. Some of these are advantages which can be attributed directly to the use of Radar in spotting the positions of the patrol vessels, while others are correlated with operating advantages which the Herald has over surface vessel echo-ranging equipment in shallow water.

Spotting the positions of patrol vessels by means of radar and directing courses from an intercept chart will decrease navigational hazards in strange close waters while making a headlong attack. Courses and speeds can be set which will place patrol vessels in the most advantageous positions for a successful assault in the shortest possible time. Patrol vessels not equipped with underwater sound gear could be rung in on the operation and expected to set the depth charges reasonably near the submarine.

The use of radar to direct interceptions on submarines presupposes a knowledge of the position of the submarine. Patrol vessels can be directed to within approximately 1,000 yards of the target from information obtained on Sono-Radio-Buoys or Cable-Connected Hydrophones providing the patrol vessel is near enough to close the target immediately. Patrol vessel pinging operations will usually be complicated by fixed targets such as coral heads and pinnacles and limited by the temperature gradient effects in shallow water.

The Herald is capable of tracking a submarine to within 20 yards over an area of three square miles, meanwhile giving the patrol vessels time to get in position for attack. Since the Herald is planted on bottom, it can be calibrated so as to recognize fixed targets such as coral heads and pinnacles, thereby reducing the possibility of mistaking them for the hunted submarine. Since the Herald is planted on bottom, it is operating in water having rather uniform temperature characteristics and

consequently the sound beam is not severely refracted. This favors long-range pinging operations on a submerged submarine. Since the Herald does not move through the water, its listening range is not limited by the presence of resultant water noise. As a result, operations are not denied the use of this valuable evaluation information.

The coordinated use of radar and Herald will enable each patrol vessel to approach the submarine to within easy range of its own sound gear without causing interference. After the patrol vessels are close upon the target, the ship's sound gear should be used while pressing home the attack, and the Herald should be used to provide evaluating information. Short communication lines between the shore control station and the patrol vessels are important. It is also highly desirable that the control station overlook the patrol area. Usually, the harbor detection station will be the most satisfactory short control station, and if this is the case HECP should turn over control of the search and attack operation.

Further consideration governing the establishment and operation of this system are given below:

Radar, which is usually mounted either on a truck or trailer, will be located adjacent to the station or as near as possible with view to satisfactory coverage of the harbor entrance. Communications will be by land line. Possibly the antenna might be mounted on top of the building and the transmitter and receiver with the "PPI" located in the operations room where the watch officer can check it frequently.

In order to establish an effective harbor defense coordinating system, it will be necessary to set up a plotting board on which interception data can be quickly spotted. The plotting board should be based on a chart of the patrol area, which should preferably be marked off in a large scale grid system. A transparent cover marked with polar coordinates on the under side with center at the station should be placed over the chart on which to mark the tracking data. Range and bearing marker arms should be fixed with centers at the chart locations of the Herald and Radar respectively.

During periods of normal watchstanding, the watch officer on duty is comparable to the officer of the deck aboard ship. He continues in this status even after a crossing has been detected and until such time as the HECP turns over control of the contact to the underwater detection station. At this point he becomes, in addition, the intercept officer and remains in that status until the sub has been destroyed or contact lost and normal search and operations restored.

Radar and Herald plotters will maintain an accurate plot on the contacts reported on a polar chart, making such conversions as necessary. The underwater detection station will be at the center of the chart and all bearings and ranges will be converted to that point. Courses and speeds on both the contact and the patrol vessel will be marked alongside their respective tracks as often as necessary. As the track on the contact developes, the intercept officer will give the patrol vessel courses to steer and will correct these courses necessary to bring the patrol vessel into a favorable position for an attack. The interception must be continually advised as to the sub's course and speed.

TEAMWORK

Successful base defense calls for teamwork and close coordination from the base commander down to the lowest rate, The officers and men of a component, such as a B1, B2A, B3, or B7, may consider themselves as belonging to a certain component in the early stages of training and assembly. All hands, however, should be thoroughly indoctrinated into the idea that as soon as they start their coordinated training, they should no longer consider themselves as personnel of an individual component.

Separate component designations are necessary only for assembly and in ordering supplies, but this is as far as it should go. From the coordinated training stage on through final assembly at an advanced base depot and during the time of active participation in the defense of a base, these components should consider themselves as an important cog in the defense and operation of a base. All parts of the defense system must be tied together to show results. It is not each component attempting to combat the enemy on its own that makes a successful defense. Instead, it is the effective coordination of all elements of the base defense system.

The accompanying diagram of telephone lines for base defense is typical of any advanced base. A few modifications may be necessary to fit a particular area. Note that there are lines between every activity that might need to take action in the defense of a base. Routine administrative circuits are not shown. In many cases, it will be impossible to lay land lines and it will be necessary to use radio for communications (reporting, etc.). In addition, land lines may be paralleled by voice radio.

Surface search components are closely allied with the activities of underwater detection components located in the same area. These underwater detection components are usually provided with a mobile surface search radar for use in the investigation of contacts on sub-

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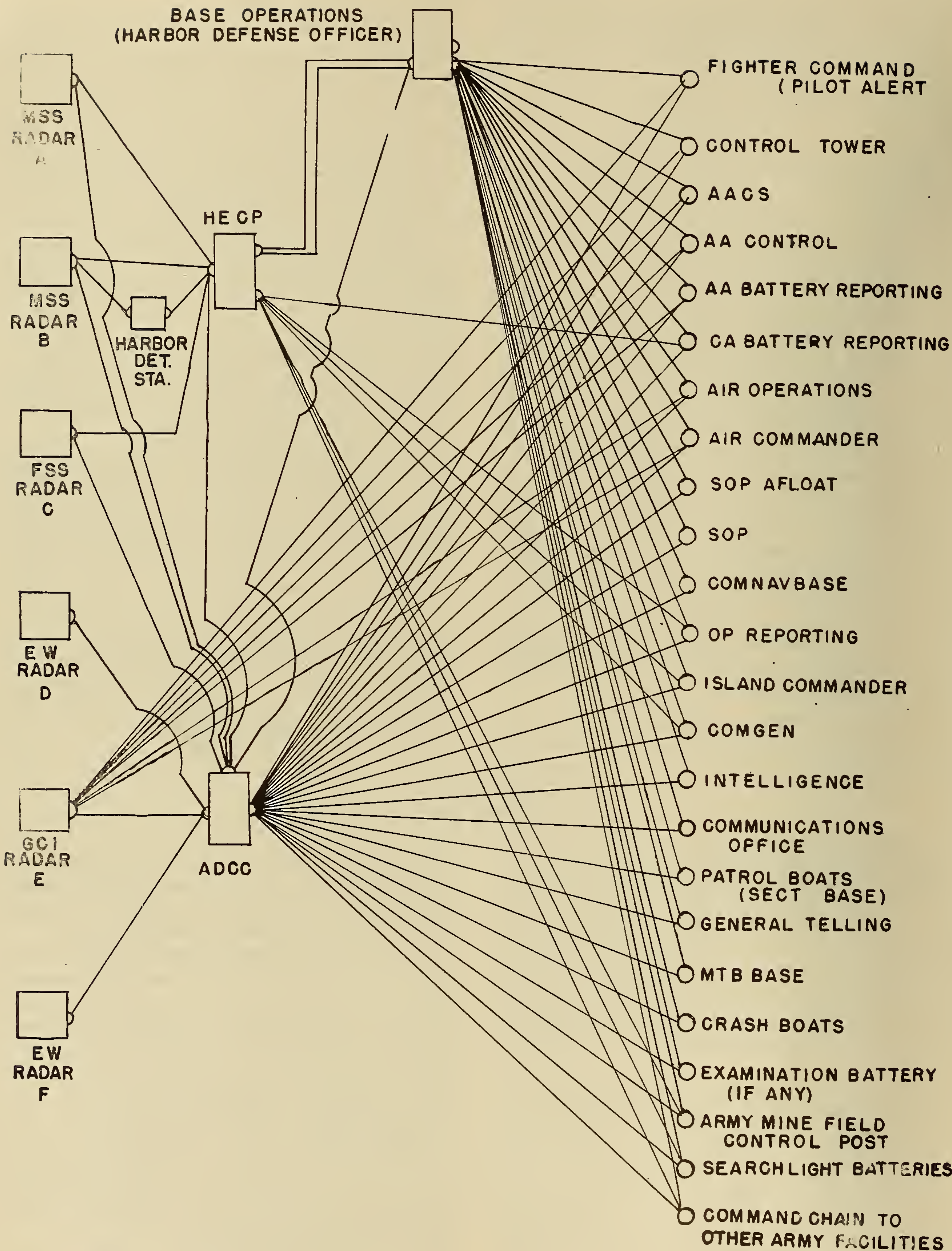
BASE OPERATIONS
(HARBOR DEFENSE OFFICER)
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AIR COMMANDER
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SOP
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OP REPORTING
ISLAND COMMANDER
COMGEN
INTELLIGENCE
COMMUNICATIONS
OFFICE
PATROL BOATS
(SECT BASE)
GENERAL TELLING
MTB BASE
CRASH BOATS
EXAMINATION BATTERY
(IF ANY)
ARMY MINE FIELD
CONTROL POST
SEARCHLIGHT BATTERIES
COMMAND CHAIN TO
OTHER ARMY FACILITIES

marines or surface craft crossing underwater Magnetic Loops or a line of Sono-Buoys. This radar is primarily concerned with this type of operation and cannot be counted on for any extensive search operations.

Due to the frequencies on which surface search radars operate, siting with respect to irregular and mountainous terrain is unimportant. However, extreme care and consideration should be given with respect to contours and obstructions so that no areas will be without coverage. If possible, it is advisable to allow for overlapping coverage, especially in the approaches to the harbor entrance. The height of the antenna above sea level will depend in part on the particular terrain.

It might be said that with air superiority and excellent search procedure, no enemy surface forces could approach any of our bases. It is not to be forgotten that in the later days of the fight for Guadalcanal, the "Tokyo Express" sneaked in undetected to bring supplies or evacuate Japs, despite our careful air searches. To avoid our searches, the Japs utilized camouflage by day and the cover of darkness by night to approach to within a relatively short distance of their objective. This same type of problem was expected during the later months of the war when our progress in the war had taken us to within the "Empire Waters" of the enemy, but no second "Tokyo Express" was ever experienced on a large scale.

With the warning obtainable through the proper use of our surface and underwater detection equipment, appropriate action can be taken to send our own ships or planes out to meet sneak raids, to alert batteries, and to warn personnel not concerned with such type of defense in time for them to take cover from possible bombardment or low-level bombing raids.

The vital importance of speed, accuracy, and brevity of reporting must be impressed upon every member of all units. The communications plan is set up so as to eliminate all lost motion and enable the proper parties to take immediate action on a contact. During the war, there was too much lost motion resulting in such long delays that the contact might easily have resulted in shelling or low-level bombing attack.

Inaccurate reporting might well be the means of missing a contact. At best, a sub contact is hard enough to track down with extremely accurate information.

Don't be guilty of the crime of "Too much information, too inaccurate and too late"!

DEFENDED HERE AND THERE

Close coordination and intelligent use of all elements of harbor defense is necessary if any one of them is to be justified. The most complete and efficient harbor detection system is not able to assault and destroy the intruder, nor is it supposed to. The best organized Harbor Entrance Control Post (HECP) is helpless unless it can put "teeth" to its challenge. The most accurate surface detection radar is ineffective unless something can be done to follow up a contact and determine whether it is friend or foe. What good is it to know the enemy is penetrating the harbor if there is no means to stop him? Unopposed, the enemy can render the best of net defenses ineffective and proceed on his mission. Without suitable harbor defense patrol vessels and adequate shore batteries, the harbor defense system is as effective as a man-of-war without armament. Unless suitable means of assault are "there" when needed, the HECP and harbor detection station and surface search radar might as well be staging in 'Frisco—maybe better so because there would be no sense of false security. Even with an adequate harbor defense patrol, coordination of many separate elements is required if the anchorage is to be considered a safe refuge for ships loaded with essential supplies and Fleet units being serviced and recuperating from a difficult job well done.

The present harbor defense plans, which were adopted by competent authority after careful consideration, have been in print for over three years. In the few instances when they were carried out, they have proved to be adequate for any occasion and capable of providing security commensurate with that existent on the Great Salt Lake. There the Fleet could safely rest at anchor without first setting up its own protective screen and even the hard-worked destroyers could recover for the next big job. There, ships loaded with essentials of war could feel assured that their cargo would feed the military might of our forces instead of the fish. There, seamen could relax before again braving the dangers of the open sea. The harbor defense plans were intended to see these ships safely in and out of their anchorage and to insure their safety while in the protected harbor. These plans have partially failed in their execution, but the existence of even inadequate defenses has often deterred the enemy from chancing an attack on helpless ships.

Fortunately for us, some of the harbors used by our forces early in the war were well protected and harbor defenses were properly coordinated. Some of these harbors were the object of enemy submarine attack. Immediate effective defensive assault resulted in some enemy submarines lost in action and even those that got away served our cause by reporting our harbors to be strongly

defended. After a few such reports had been circulated to enemy submarine commanders, it is apparent that they were impressed that a harbor was not the best point of attack even though there was intriguing bait within. Thus, some of that "Stateside Stuff" made our job easier in advanced bases. It requires only one such successful attack to set up a scream for more adequate harbor defenses.

It is not within the scope of this article to attempt the development of adequate harbor defense plans, since it is a subject which in itself would fill a book. It is more fitting to present some specific instances to illustrate the value of intelligence and coordination and cooperation with respect to harbor defenses. In presenting these narratives, the indulgence of officers concerned is desired on the basis that their experience may be helpful to others.

A vessel, on entering an advanced base harbor, was challenged by HECP but failed to reply. The book says to fire a shot across the bow of the invading ship followed by a second shot "dead on" if the vessel fails to stop or respond to the challenge. An officer passenger, in telling this narrative, says that in view of the fact that the vessel had one hold loaded with dynamite he was much relieved by the inefficiency of the HECP. However, the net gates were opened for this vessel to enter the anchorage which was already occupied by a large number of combatant ships. Upon being questioned, the watch officer at HECP stated he didn't expect that ship until the next day—which, of course, completely explained the break in procedure—to nobody's satisfaction.

A destroyer task force was scheduled to enter an advanced base anchorage at break of day according to a despatch received at the HECP. This task force actually returned during the late evening to sail blissfully through the net gate which, of course, was not open. Everybody was blamed except the task force which failed to send a correction to the despatch. The HECP had spotted their approach and had challenged them, but no reply was forthcoming. By their negligence, this task force had not only betrayed the protective value of HECP but had destroyed the net protecting an anchorage full of ships.

Hydrophone sounds were picked up on Sono-Radio-Buoys outside an advanced base harbor. The report was made to HECP, and since visual and radar search did not disclose the presence of a surface vessel the nets were buttoned up and patrol vessels twelve miles away were notified. Before they arrived on the scene, a destroyer had been warmed up and was on the search and had dropped several patterns. The destroyer probably got the submarine and had finished the job the patrol vessels were supposed to be on duty to accomplish. The patrol area established by the base commander was much too far to seaward. The patrol vessels were actually stationed for off-shore patrol vessels to form a tight screen. Still, the submarine slipped inside. Under these circumstances, the patrol vessels would better have been disposed as harbor defense vessels and in locations where the harbor detection system could overcome the need for more screening vessels. After an instance such as this, it is logical for the task force commander to set up his own defensive system and disregard that provided by the base.

In the early days of the war, harbor defense patrols were provided by destroyers because submarine chasers were not available in sufficient numbers to properly defend all harbors. In one such instance the harbor detection station reported a Loop crossing to HECP. Since nothing was visible in the Loop area, the integrity of the harbor detection officer was questioned and a long conference ensued over the telephone line. HECP eventually decided not to take further chances and notified the destroyer patrols. The destroyers concentrated their search in the vicinity of the Loop. Since they had not been notified how much time had elapsed since the contact, this was the logical procedure. HECP apparently did not appreciate the importance of making allowances for the submarine to depart from the Loop area. Whatever the reason, the destroyers conducted their search in the wrong place. A German submarine surfaced just before nightfall off a second harbor detection station 15 miles away and proceeded to sea on the surface. The submarine was identified by an enlisted man at the harbor detection station who had spent 20 years in submarines. HECP again could not be convinced for a considerable time but eventually sent planes to apprehend the submarine. The submarine submerged during the bombing and was not seen again. This assault was assessed "probably sunk."

HARBOR DEFENSE TRAINING IS DESIGNED TO INCREASE EFFICIENCY

The present naval advanced bases have in their harbor defense group components which are trained initially in their individual specialties. These groups are provided by separate components as part of a standard naval advanced base unit such as a LION, CUB, or GROPAC, or in some instances by separate request.

To save valuable time in setting up the installation and operation of these components and to attain a more coherent organization, all naval advance base units which include harbor defense components received coordinated

training in the United States as a harbor defense group. After completion of technical training in their individual specialties, the appropriate components are formed into a unit and given coordinated component training. This coordinated training program includes the Harbor Entrance Control Post, the underwater detection component, the surface detection component, the net and boom component, the harbor defense antisubmarine patrol component, and the harbor patrol component.

This organization, known as a harbor defense unit, is headed by an officer specially selected for his experience who acts as harbor defense officer on the staff of the naval advanced base commander.

An important phase of this training program is to insure that each individual component is cognizant of the responsibilities and operation of the other components in the harbor defense organization. By appreciating each other's problems, it is possible to accomplish the installation of the various defense facilities in the shortest time. Those components requiring more time and facing greater difficulties in the installation of their equipment can be assisted by other components. The problems which may be anticipated on the arrival of the unit at its destination are fairly well investigated and the organization of the unit as a whole firmly established, not only to expedite the installational work but to correlate an efficient harbor defense operational organization.

This training program results in an increased efficiency in the installation, operation, and maintenance of the harbor defenses at the advanced base.

Although the Japanese exhibited nothing like the highly specialized swimmer equipment characteristic of both the Italians and Germans, they used swim fins and padding, which is presumably to protect swimmers against underwater explosions. In attacks at Luzon and Lingayen Gulf, improvised limpets were placed on or near ships with some resulting damage. Japanese swimmers used a number of different tricks to approach their targets in as inconspicuous a manner as possible. They approached under boxes, old life preservers or other debris floating in a harbor. At Luzon they used a small bomb with a pull-ignited delay fuse all placed in a watertight box resembling a small coffin. The box was pushed to the target by one or more swimmers. In Lingayen Gulf, several of the swimmers had charges strapped to their bodies apparently with the intention of blowing themselves and their targets up. Some Japanese swimmers booby trapped themselves.

The best defenses against this type of attack are illumination, small depth charges laid at irregular intervals, a very sharp picket patrol around ships, and armed deck watches.

Op-30B1-MG
(SC) A16 (A&N)
Serial 041230

NAVY DEPARTMENT
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON

5 November 1940

From: The Chief of Naval Operations.
To: The Commandant, First, Third, Fourth, Fifth, Sixth, Seventh, Eighth, Tenth, Eleventh, Twelfth, Thirteenth, Fourteenth, Fifteenth, and Sixteenth Naval Districts.
Subj: Joint Defense of Harbors.
Ref: (a) FTP 155.
Encl: (A) Outline Diagram.

1. Due to the increasing importance of adequate joint provisions for the defense of harbors, it is desired to point out a feature thereof developed from recent information on the subject.

2. Commandants, in their participation in local joint planning, under the provisions of reference (a), and in the formulation of their district plans, should give careful consideration to the local application of the contents of this letter.

3. Local plans must provide for prompt and decisive action, from the time of their execution, against air, submarine or surface action by enemy or neutral craft, particularly by strategem, threatening our harbors or the shipping using them. Direct and quick acting group control of the forces jointly involved in the defense of a harbor is essential to effectiveness in meeting prospective situations of this nature. Since such threats will be primarily of a naval character, Commandants concerned should logically, through local joint planning committees, initiate proposals as to effective counter measures.

4. (a) Information at hand indicates that the best way to attain the above objective, i. e., immediate, coordinate and effective measures by the forces concerned, is to interpose at each harbor so warranting, in the lines of command of such Army and Navy local forces, a joint control station. Here, all information bearing on subject measures should be received with least possible delay. This station, designated "Harbor Entrance Control Post," should be the "nerve center" of the system and continuously manned by two "Duty Officers," one Army and one Navy, with assisting personnel. Each Duty Officer should be empowered and instructed to initiate, in the name of the commander of the forces concerned and as required in any situation, immediate, decisive and coordinated action, on the part of the respective Army and Navy forces under control of the station. Should such information demand action by, or be of value to, other forces, request or report should be made to the proper commander, Army or Navy.

RESTRICTED

(b) The method of local coordination to be applied here, i.e., by mutual cooperation or unity of command, should, subject to senior plans, be determined locally and prescribed in the local joint plans concerned.

5. Organization, task assignments and the degree of control to be imposed on commercial shipping are matters for local determination. However, the machinery for a high degree of this control should be available for functioning when necessary. The control should normally be based on considerations of the Category of Defense, importance of the port, conveniences to the shipping involved and current information. For purposes of demonstration, there follows an outline of the principal elements involved, this being also shown graphically in Enclosure (A).

(A) Harbor Entrance Control Post.

(1) Functions and personnel as noted in par. 4.

(2) Requirements
(a) Clear View
(b) Signal Tower
(c) Communications, direct and continuously manned, to—
Forces directly controlled including (B) to (H) below.
Inshore Patrol Headquarters.
Army Harbor Defense, Headquarters.
Army Aircraft Warning Service.
This post may probably be so located, in an already planned shore unit of the local Army or Navy forces involved, as to minimize need for additional communication personnel and circuits.

(B) Underwater Defenses.

(1) Listening Posts including:
(a) Army installations.
(b) Navy installations as necessary in addition to (a). Where necessary for protection of shipping, this should include loop or loops on the bottom well to seaward and additional listening devices in the more restricted parts of the harbor. Availability of material, technique and prospective locations of these installations, not already covered, will be treated in separate correspondence.

(2) Net and Boom protection against submarine and fast motorboats, including gates and gate vessels (Navy).

(3) Army Minefield Controls.

(C) Harbor Batteries.

(1) Army A.A. Batteries, searchlights and locators.

(2) Navy A.A. automatic weapons, within naval reservations, as authorized.

(3) Army harbor defense batteries, fixed or mobile.

(4) A.A. Batteries of Fleet vessels present, as directed by S.O.P.A., and coordinated with those of the Army.

(D) Aircraft units that are assigned tasks in defense of harbor.

(1) Army group.

(2) Navy group.

(E) Patrol Vessels. (Navy)

(1) Harbor entrance patrol to cover following functions:

(a) Entrance control vessel to insure against unauthorized entrance. This check should be in addition to any other applied by either outer or harbor patrols.
It may comprise—
Search for unneutral character, clearance through gate to temporary berth for further examination, definite clearance to inside berth or other procedure as dictated by circumstances.
Its result should be made known to the Harbor Entrance Control Post.

(F) Coastal Lookouts. (Navy)
While this group is not necessarily concerned exclusively with the protection of any one harbor area, those in position to so function should be in immediate communication with the Harbor Entrance Control Post to facilitate prompt reports of suspicious craft in the vicinity. Continuous watch should be kept for actual or suspected mine laying in the harbor or its approaches by aircraft or otherwise.

(G) Balloon Barrages. (Army)

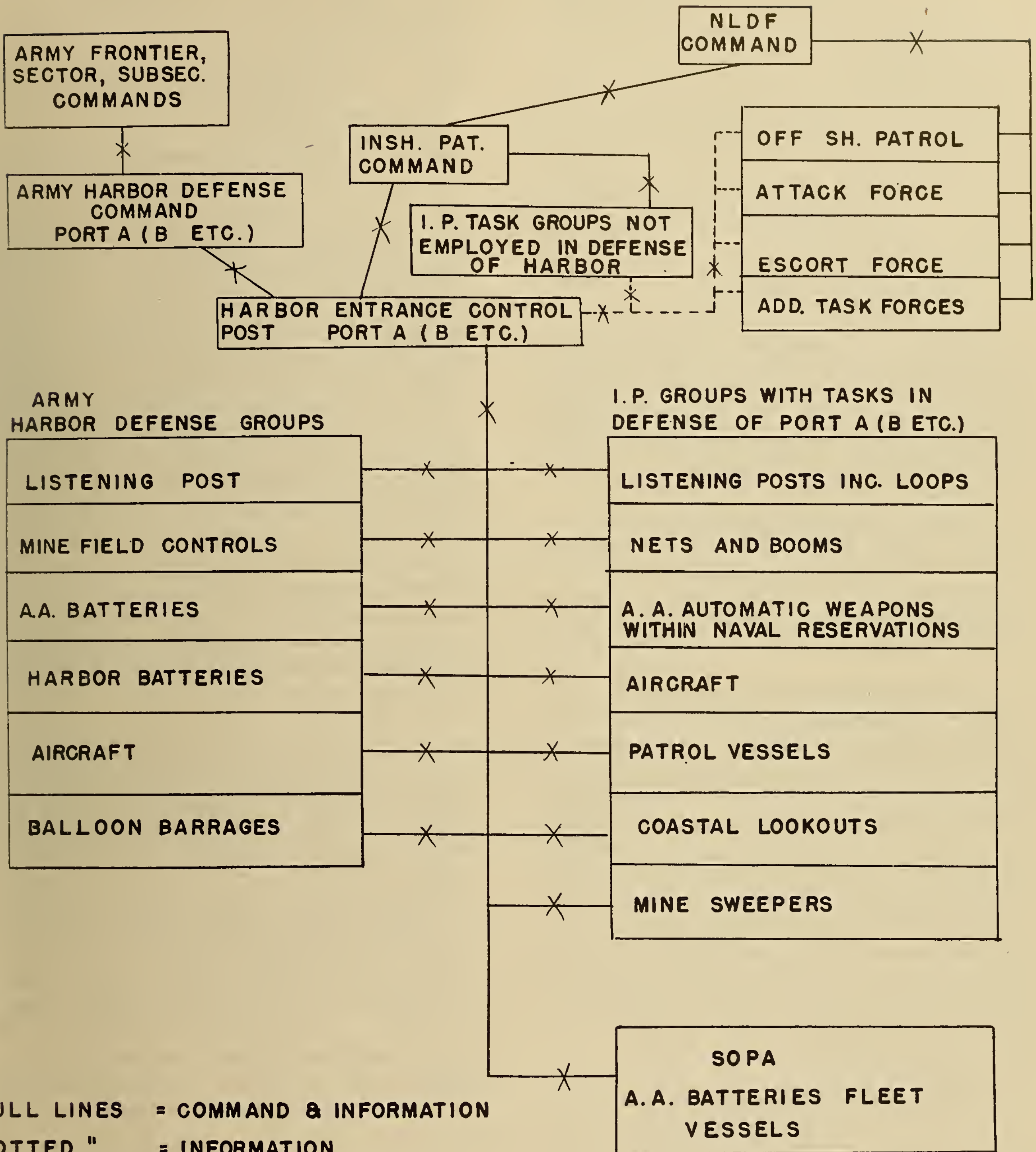
(H) Mine sweepers. (Navy)

6. As will be noted the above scheme involves only the Army Harbor Defense Command and, for the Navy, those groups of the Inshore Patrol assigned tasks in the defense of the harbor concerned.

7. The subject matter of this letter has been coordinated with the War Plans Division of the General Staff of the Army with a view to its consideration by Local Joint Planning Committees.

H. R. STARK.

JOINT DEFENSE OF HARBORS



FULL LINES = COMMAND & INFORMATION
DOTTED." = INFORMATION

ENCLOSURE (A)

[redacted]

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NAVY DEPARTMENT
OFFICE OF CHIEF OF NAVAL OPERATIONS
WASHINGTON 25, D. C.

9 December 1944

From: CNO

To: BuPers

Subj: Harbor Defense Unit—Establishment and Training of.

Ref: (a) CNO ltr Op30–3E2 Serial 01264330 of 10 Oct. 1944 to CinCPOA.

Encl: (A) Copy of reference (a).
(B) Copy of reference (b).

1. Reference (b) recommends that the establishment and organization of the Harbor Defense Unit as proposed in reference (a) be approved. The Harbor Defense Unit and the Harbor Defense Antisubmarine Patrol Component are to be added to the Catalogue of Advanced Base Functional Components.

2. BuPers is requested to take necessary steps to include the Harbor Defense Antisubmarine Patrol Component in the harbor defense coordinated training program at the San Pedro Section, San Pedro, Calif., and to implement the organization and training of the Harbor Defense Unit.

3. BuPers is requested to order officers for training as Harbor Defense officers for Advanced Base Harbor Defense Units. These officers should be selected with special attention given to their organizing ability, initiative, leadership, and judgment. It is highly desirable that they shall have had practical experience in setting up and operating harbor defense systems, preferably at advanced bases. The Harbor Defense officers of major bases normally should hold the rank of at least lieutenant commander. Since the effectiveness of the harbor defenses will depend to a great extent on the capabilities and personalities of the Harbor Defense officers, it is requested that the names of officers contemplated by the bureau for this duty be submitted to CNO for approval before orders for training are issued.

4. BuPers is requested to order two lieutenant commanders and two lieutenants to the San Pedro Section, San Pedro, Calif., at the earliest practicable date for training as Harbor Defense officers, and to maintain this level until the actual area requirements are determined.

[s] W. R. PURNELL.

10 October 1944

Op30–3E2 cwp
(SC)S68
Serial 01264330

From: CNO

To: CinCPOA

Subj: Trained Harbor Defense Unit—Proposed Establishment of.

Encl: (A) Proposed Advanced Base Harbor Defense Unit.

1. Harbor defense components have in the past been trained and sent to advanced bases as individual teams. Study of installation and operational problems at these bases indicates that it would be highly desirable for all harbor defense components for a specific base to be organized and trained as a complete unit prior to departure from the United States. As a preliminary measure to the establishment of such units the Harbor Entrance Control Post, Underwater Detection, Surface Detection, and Net Components are at the present time being given coordinated training at San Pedro after having completed training in their individual specialties.

2. The harbor defense team is not complete without a harbor defense patrol consisting of a suitable number of vessels properly equipped for antisubmarine operations. It is proposed to form such a component consisting of vessels which have already had experience in antisubmarine coastal patrol. This component will be given coordinated training with the other harbor defense components.

3. It is further proposed to assign a qualified officer to supervise the assembly and training of each harbor defense unit prior to movement overseas. Upon arrival overseas, this officer will be well qualified to become the Harbor Defense officer on the Staff of the Base Commander.

4. Further details of the proposed harbor defense unit are given in Enclosure (A).

5. It is requested that CNO be advised whether or not the above proposals meet with the approval of CinCPOA.

6. Transmission by Registered Guard Mail or U. S. registered mail is authorized in accordance with Article 76 (15) (e) and (f), U. S. Navy Regulations.

[s] F. J. HORNE
Vice Chief of Naval Operations

CC: CominCh
Op05
Op12

ENCLOSURE (A)

PROPOSED ADVANCE BASE HARBOR DEFENSE UNIT

1. The components listed below form the Harbor Defense Unit which is proposed for assembly and training in the United States before moving overseas as part of a Standard Advanced Base Unit.

(*a*) Harbor Defense Officer
(*b*) Harbor Entrance Control Post Component
(*c*) Harbor Detection Component
(*d*) Surface Search Radar Component
(*e*) Net and Boom Component
(*f*) Harbor Defense A/S Patrol Component

2. The scope of component training is indicated as follows:

(*a*) The Harbor Defense Officer will when practicable be selected from those officers having previous advanced base experience. He will receive a short course of instruction at each of the component training schools, after which he will supervise the assembly and coordinated training of his complete unit.

(*b*) The Harbor Entrance Control Post Component receives specialized instruction in harbor defense tactics, liaison with all military forces and practical experience in operating an HECP including use of recognition signals, challenge procedure, identification by silhouettes, visual and radio communications, coast artillery, controlled mine fields, nets, harbor detection reports, and patrol vessels. Instruction is also given in the installation, operation and maintenance of HECP equipment.

(*c*) The Harbor Detection Component receives specialized technical instruction in the use of various types of harbor detection equipment, including theory of operation and evaluation and reporting of contacts. The training includes practical experience in installation, operation and maintenance of the equipment. Sufficient seamanship and small boat handling experience is obtained to enable personnel to make sea installations.

(*d*) The Surface Search Radar Component receives specialized technical instruction and practical experience in the installation, operation and maintenance of its equipment including theory of operation and evaluation and reporting of contacts.

(*e*) The Net and Boom Component receives special instruction and practical experience in the use, installation, operation, and maintenance of the various types of nets and booms. Complete instruction is given in seamanship, small boat handling, net tender operation and use of ground tackle in the installation of net equipment. Tactical use of the various types of nets is stressed during the component training course.

(*f*) The proposed Harbor Defense A/S Patrol Component as presently planned will be composed of coastal patrol vessels complete with crews and spare parts that have been operating for a considerable time and consequently will require only coordinated training. These vessels have excellent seakeeping qualities, are equipped with echo-ranging equipment, SF radars, two searchlights, 7.2 launchers MK XX, depth charges and a 20-mm. gun. They are gasoline driven, have a lifting weight complete with slings but without fuel or ammunition of sixty tons, and will make 18-20 knots speed. The crew consists of one officer and ten enlisted men. In addition to the requirements for new bases it is expected that a number of these components will be desired for bases already established.

3. The coordinated training program is designed to give instruction to all of the harbor defense components in the installation and operation of an organized harbor defense unit. Special consideration is given to its installation and operation on a temporary basis shortly following the amphibious operations and to its consolidation into a more permanent installation for continued operation at the newly formed advanced base. Coordinated training will be given to all harbor defense components whether they are requested by Area Commanders as parts of a complete unit or as individual components.

NAVY DEPARTMENT
OFFICE OF THE CHIEF OF NAVAL OPERATIONS
WASHINGTON 25, D. C.

8 April 1944

From: CNO
To: BUPers
Subj: Fixed Underwater Detection Station—Policy in Regard to Officer Complement.

1. The following policies will determine the officer complement for normal operation of fixed underwater detection stations. Exceptions may be made at the request of the commander of the areas or districts concerned:

(*a*) At each station there should be assigned at least one officer technically qualified to supervise all ordinary maintenance and repair.

(*b*) At each station there should be a duty officer immediately available. It is considered that normally this requirement will be satisfied by two officers, one of whom will be the technical officer required by paragraph 1(a). If the detection station is combined with the HECP the detection duty may be assumed by the HECP watch officer.

(*c*) At each advanced base having two or more detection stations one additional officer should be assigned as base detection officer.

2. The installation of certain fixed underwater detection equipments requires special knowledge and experience. Therefore, with each movement to an ad-

vanced base which includes Loops, Heralds, or Cable-Connected Hydrophones, an installation team consisting of an officer and two men should be assigned temporarily. This personnel should be released and returned to the assembly point when the installation is complete.

3. It is considered desirable that naval districts hav- more than two fixed underwater stations have a staff officer to coordinate the activities. It is expected that area commanders will require a corresponding staff officer. Such officers should be familiar with the latest developments in regard to the capabilities and limitation of the equipment.

4. This letter should not be construed as modifying the Catalogue of Advanced Base Components. The functional components described therein are primarily for procurement planning purposes, and when practicable will be modified to meet the requirements of the base to which assigned.

[s] W. S. Farber
Sub Chief of Naval Operations

Navy Department
Office of Chief of Naval Operations
Washington 25, D. C.

30 June 1941

Op-30-D-FM
(SC)A16(A&N)
Doc 32274
Serial 062530

From: The Chief of Naval Operations
To: Commandants, First, Third, Fourth, Fifth, Sixth, Seventh, Eighth, Tenth, Eleventh, Twelfth, Thirteenth, Fourteenth, Fifteenth, and Sixteenth Naval Oistricts.
Subj: Harbor Entrance Control Post—Function of in Joint Defense of Harbors. (Ltr. from Ch. of Staff, War Dept., dated 23 June 1941, file WD 660.2 (5-29-'41) MC-E to CNO.)
Encl: (A) Mission, General Operation and Desirable Location of a Harbor Entrance Control Post.

1. It seems desirable to clarify to all concerned, the functions of a Harbor Entrance Control Post. For this purpose, enclosure (A), drawn up to present a broad conception of this distinctly new feature of joint operations in local defense of harbors, is forwarded for guidance. It is understood that the War Department is distributing it to the appropriate Commanders in the field for their guidance.

[s] R. E. Ingersoll
Acting

(ENCLOSURE A)

Mission—General Operation and Desirable Location of a Harbor Entrance Control Post

1. A Harbor Entrance Control Post is a central point for the coordination and joint operation of the Army and Navy elements of the harbor defense system, whose mission is:

Mission—To collect and disseminate information of activities in the defensive sea area; to control unescorted commercial shipping in the defensive coastal area; and to take prompt and decisive action to operate the elements of the harbor defense; in order to deny enemy action within the defensive coastal area.

2. This post is visualized as one continuously manned by an officer of both the Army and Navy and the necessary assisting personnel for clerical and communication duties, where the Army and Navy officers are the Senior Local Commanders of their respective services, or their direct representatives with authority to take the action necessary to accomplish the mission as stated above.

3. When the Army or Navy officer on duty at the Harbor Entrance Control Post is a representative of the Local Senior Commander his authority will have to be defined by the Senior Officer whom he represents, whose judgment must be based upon the task which is to be accomplished as expressed in the mission.

4. The ideal location for such a post is one which will command a complete view of the harbor approaches and the harbor itself. The ideal housing is to place it in the same building with the Army's harbor defense command post. Neither of those ideals can probably be uniformly realized at all points where Harbor Entrance Control Posts will be established.

5. Each Harbor Entrance Control Post should be equipped with a chart room where information relative to enemy activities, or other activities which are potentially important, may be plotted on a graph or situation map of the defensive coastal area; and with all of the communication facilities necessary to receive and disseminate information and to communicate with the elements of the harbor defense system. Whenever it is practicable it seems desirable, in order to eliminate as much communication installation as possible, to place in the Harbor Entrance Control Post building a receiving station for underwater listening posts, Indicator Loops and Sono-Buoys and a visual signal station. This arrangement expresses an ideal which also probably cannot be uniformly realized, but to whatever extent such an arrangement is practicable, it seems desirable to make it so.

Approved 29 May 1941

H. R. Stark
Admiral, U. S. Navy
Chief of Naval Operations

Approved 23 June 1941

Geo. C. Marshall
General, U. S. Army
Chief of Staff,
U. S. Army

UNITED STATES PACIFIC FLEET
THIRD FLEET

7 January 1945

1st Endorsement on ComSeron TEN ltr., serial 00274 dated 8 December 1944.

From: Commander THIRD Fleet.
To: Commander-in-Chief, United States Fleet.
Via: Commander-in-Chief, U. S. Pacific Fleet.
Subj: Torpedoing of U.S.S. *Mississinewa* and events in connection therewith.

1. Forwarded. The loss of an able fleet oiler is regretted, but this command is pleased to see the cool courage of its crew expressed during the abandonment of the stricken vessel. The prompt action by salvage and fleet tugs was gratifying. Had the oiler had more buoyancy forward, the fires would have been extinguished and the vessel saved. The desire of all hands to cooperate and do a job is most gratifying.

2. The comments of the Commanding Officer, U.S.S. *Reno*, are appreciated. It is understood that Commander Forward Area has authorized the netting of Zowatabu Channel and the placing of baffle nets in Towachi and Mugai Channels. Until Mugai Channel is baffled or gated it is directed that no vessel of any description be anchored in direct line of the channel.

3. The lessons learned from this torpedoing are: (1) That all fleet anchorages must be completely netted. (2) That baffles or gates must be used in the channel. (3) That sufficient patrol vessels, preferably of the PC and SC class, must be assigned to these anchorages for the single purpose of patrolling that anchorage so as not to be dependent on combatant units that return for required upkeep periods.

[s] ROBT. B. CARNEY,
Chief of Staff

[redacted]

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Section II

HARBOR UNDERWATER DETECTION

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Section II—HARBOR UNDERWATER DETECTION

FOREWORD

FIXED HARBOR UNDERWATER DETECTION

One of the first things that personnel must learn about Harbor Underwater Detection is that the devices used are in no respects offensive weapons. Instead, all of them perform the highly important function of detecting the enemy and, in turn, aiding an assigned striking force of patrol craft to the scene of contact where actual combat begins.

The high degree of accuracy which today is associated with Harbor Detection devices represents a long period of intense study, research, testing, and development. Unlike a number of other implements of warfare which had been developed and used during World War I and constantly improved during the years of peace that followed, Harbor Detection consisted of but one type of detection, the Magnetic Indicator Loop, when the emergency was declared in 1940. This Loop was not considered very effective. It had been developed during World War I, but all plans for improvements were cancelled when the Armistice was declared.

Shortly after the United States was placed into a state of national emergency, Naval authorities realized that among the many other high priority details they had to face should war be declared was the one of protecting harbors and anchorages against the decided German submarine threat. In making this decision, it was also realized that if a harbor could adequately be defended by fixed detection devices the available patrol craft could be assigned to convoy duty instead of being used as patrols at a harbor's entrance. Destroyers, PC's and SC's were not numerous enough to be limited to such duties, if other facilities could be developed to give the same results.

When research engineers received the "go ahead" signal from the Navy, their first undertaking was on improving the Magnetic Loop. Their work was so effective in this field that when the first Loop installation was made on an experimental basis at Cape Henry, Virginia, in the summer of 1941, it was considered at least 10 times as sensitive as the one of World War I. The experiment was a success, and Harbor Underwater Detection had its first useful and adequate device for its job in the war that was to start within the next few months.

While developments were being made on the Loop, research was being made on a listening device which was to be known as the Sono-Radio-Buoy. The first model of this new type of detection made its appearance in October of 1941, after going through experimental tests at Key West, Florida. This particular model of the Sono-Radio-Buoy was not so effective and practical as the improved type that was in use when the war ended, but it was considered a very excellent beginning. Thus—the second Harbor Detection device was introduced and accepted.

The development of the Echo-Ranging Herald gear took much more time and research than had been required for the first two detection units. Whereas the Sono-Radio-Buoy was developed for a sonic frequency, the Herald was planned for super-sonic. Its purpose, too, was different. Instead of affording merely a listening detection, the Herald was to track down a target by echo-ranging, and, by this method, aid standby patrol craft to go to the exact spot of contact to make an investigation and take whatever action that was deemed necessary. The Herald would put them on the scene, because it would tell the detection watchstander the exact range and bearing of contact.

Observers were invited to Fishers Island, New York, the site of the one of the two sound schools the Navy had established for training of personnel, in August of 1942 to witness the results of the first Herald detection, a model known familiarly to detection personnel as "Sadie the Seamonster." Like the first Sono-Radio-Buoy, "Sadie" was not considered as good as research engineers had hoped it to be, but it was a good beginning and a good foundation for further study and development.

That, briefly, is the way Harbor Detection began its work in the war. Later, research work gave the Navy the Cable-Connected Hydrophone, the Short Pulse Herald, the Multi-Turn Loop, and the Underwater Electrical Potential. Improvements continued to be made on the Loop, the Herald and tthe Sono-Radio-Buoy—their sea units and their receivers.

After installations were made in continental United States harbors, there was no doubt but that Fixed Harbor Detection devices could perform an efficient harbor defense. These devices offered as good and in the majority of cases much better protection to the entrance of harbors as could patrol craft with their sound gear.

These units were installed in practically every major and medium continental U. S. harbor in the few months that followed and as they were made available, and by the end of 1942 were being shipped to the South Pacific to begin the huge advanced base Harbor Detection program that was planned. Harbor detection had very definitely found its place in the war effort, and steady progress was made from then until hostilities ceased. This progress allowed Harbor Underwater Detection to be installed in major and medium ports along the East and West coasts of the United States, the Aleutians, South Pacific, North Africa, Sicily, Italy, Southwest Pacific, Central Pacific, France, the Philippines, the Canal Zone, Australia, South America, and when the Japanese surrender came there were several components assembled in California for movement to Japan. A comparatively unexplored field of warfare during the national emergency period before the war had become a world-wide project.

Harbor Underwater Detection during the war received many commendations and "well dones." All of these commendations came because Harbor Detection personnel took great interest in their work and effectively used the instructions given to them at training schools in making as complete an installation as possible under existing circumstances. They knew that unless they took full advantage of the equipment allotted to them, unless they made wise decisions in properly installing that equipment, and unless they kept abreast with the latest developments in detection, their job would be of little use.

The purpose of this guide to Harbor Underwater Detection is to instruct all Naval personnel who are to study harbor defenses in the post-war period the *proper* way to operate a station and the equipment that is included therein. It must be remembered that only through proper installation and operation can Harbor Detection do its job. Without this aim to perfection, no harbor can be called a protected harbor.

Detailed instructions on maintenance are presented in booklet form with each piece of detection equipment, and bibliography of pertinent publications is printed with this manual to further educate the officer or watchstander on what is commonly called today—"The Science of Harbor Detection."

WHAT IS HARBOR UNDERWATER DETECTION?

Harbor underwater detection, a little publicized field of Naval defensive warfare, is a part of the answer to enemy submarine threats to ships in allied harbors the world over. As the name implies, harbor underwater detection is a Navy activity whose function is to detect the approach and location of enemy surface and submerged vessels, give warning, and provide subsequent information necessary to coach counterattacking surface and aircraft in for the kill.

Let it be clearly understood that harbor detection devices are not in themselves capable of offensive action. Instead, they perform much the same function against surface and submersible craft that radar does against aircraft.

The efficiency of operational control which HECP exercises is directly dependent upon the receipt of reliable information from harbor detection activities. It is the responsibility of the detection activities to discover the presence of any vessel as it passes the detection line and to, in turn, give this information to HECP. For vessels on the surface, this is accomplished by radar and underwater detection. For vessels under the surface it it accomplished by underwater detection alone. To insure detection of any vessel regardless of size or type, a number of different devices are used in the detection line.

Most vessels are built of steel and have magnetic properties; consequently, one device is used which will detect a ship's magnetic field. Propeller and engine noises are transmitted to the water and provide another means of detection by listening devices. That part of a vessel below the water line provides a surface from which underwater sounds of short duration may be reflected, thereby providing the requisities for echo-ranging detection devices.

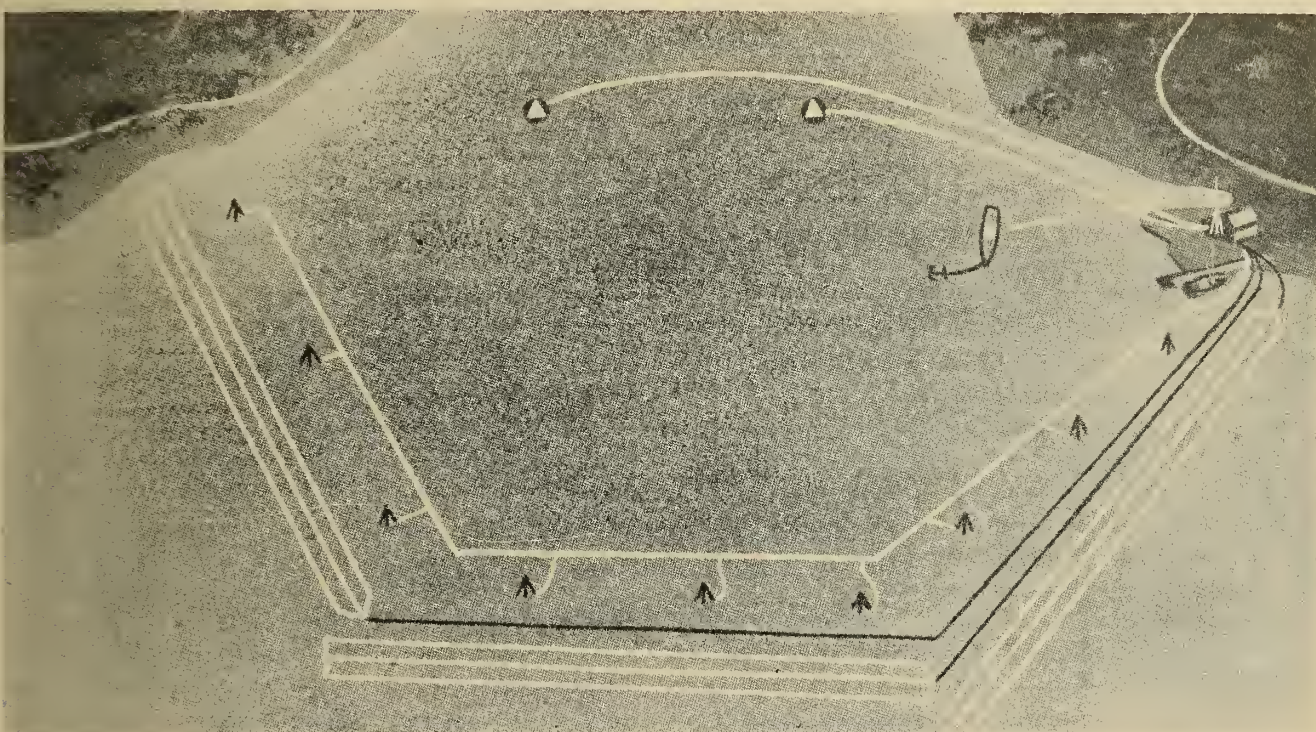
Harbor Echo-Ranging and Listening devices are used to provide precise tracking information to the patrol vessels and are placed adjacent to the patrol area inboard of the listening and magnetic detection lines. Magnetic Indicator Loops are placed to seaward, because experience has shown that they are more reliable in detection ability. Since the Magnetic Loop is less dependent on the human element for its warning efficiency, it lends itself to use for first warning. The Sono-Radio-Buoys or Cable-Connected Hydrophone listening devices are placed just inboard of the Loops where they serve to indicate what segment of the Loop has been crossed and to provide additional information as to the direction, speed, and type of vessel. The duty officer at the detection station evaluates the information obtained on his instruments and passes it to HECP where appropriate action is taken.

DETECTION TACTICS

Fundamentally, it is the purpose of fixed underwater detection to deny the enemy the element of surprise so vital to the successful culmination of sneak attack against a harbor. Therefore, harbor detection strategy is based on the theory that calculated risk of harbor penetration is at a minimum when devices which utilize several detection principles are so disposed in the harbor approach that great detection depth and early warning are possible. Strategical considerations are aimed at providing a harbor detection line which cannot be evaded and which is as firm as topographical factors and technical limitations of the equipment will permit.

placed behind the Magnetic Indicator Loop for the second line of detection. Sono-Radio-Buoys perform the same function as do Cable-Connected Hydrophones but send the underwater sounds ashore by means of radio instead of through a cable. They are used in place of Hydrophones when water depths are excessive or when time does not permit the laying of submarine cable required for the installation of Hydrophones.

Tests have shown that a submerged submarine running at "silent speed" usually cannot be heard when it is more than 500 yards from a listening device, so Hydrophones and Sono-Buoys are installed 1,000 yards apart



All harbors are not so ideally laid out as the one shown in this diagram to afford complete underwater detection installations with little difficulty. This diagram is presented to show how an underwater detection plan appears under ideal conditions—with detection officers and enlisted personnel being challenged to make their installations, regardless of the harbor conditions, in accordance with this study. Beginning outboard there are, first, three Magnetic Indicator Loops; second, nine Cable-Connected Hydrophones; and, last, two Heralds. The Heralds scan the hunting area between the Cable-Connected Hydrophones and the Heralds. Moored out of the channel and adjacent to the detection station is the patrol vessel which is in radio communication with HECP and the detection station.

The Magnetic Indicator Loop, which is laid on the ocean's bottom, records any distortions of the earth's magnetic field caused by the presence of an iron body over it. The magnetic field of a vessel passing over the Loop is recorded on chart paper and the recorder mechanism in the station sounds an alarm.

The Cable-Connected Hydrophones detect underwater sounds generated by a vessel's propulsion machinery and transmit the resultant electrical impulses to a shore station by means of a submarine cable. They are to force any vessel transiting the protected area to pass within range of one of them. Asonic contact will come in stronger over the closer Hydrophone or Sono-Buoy, thus enabling the watchstander to make approximation of the target's location. By analyzing target noises, a trained operator can usually determine the type and speed of the ship heard. The information thus obtained confirms an inbound Loop contact and is of great assistance in determining the type of counteraction necessary.

The Herald is a super-sonic directional listening device able to transmit a short, powerful super-sonic signal and then receive the reflected echo from an underwater target in such a manner that its distance and bearing are known. Heralds are used as the third line of detection since they give precise information valuable in directing the harbor patrol to the target.

In the detection station of the latter period of the war, surface search radar complemented the detection system by giving valuable information during good visibility and by providing a dependable means of determining whether a contact on detection equipment during periods of poor visibility was surfaced or submerged. The SO–12 surface detection radar equipment, when installed properly and operated intelligently, should detect the presence of a periscope above the surface of calm water at 3,000 yards.

Normally, first and second lines of detection are placed 1,000 yards apart. It is considered that by the time a target has passed the first line of detection and is approaching the second, the target's intentions will have been determined. Therefore, in order to provide an area in which unfriendly craft may be hunted down and destroyed, the third line of detection is placed as far inboard as the maximum dependable range of the Heralds will permit. The "hunting area" thus created is that part of the harbor approach in which the harbor antisubmarine patrol vessel, acting on information obtained from both the second and third lines of detection, can attack and destroy an unfriendly submarine before it reaches a position from which it can fire torpedoes into the anchorage. The third line of detection gives the detection station specific information as to the target's course, speed and location so that this information can be coordinated with information as to the patrol vessel's position obtained from radar, enabling an officer at plot to coach the patrol vessel by radio to the target's position. Once near the target, the patrol vessel can obtain contact with its own echo-ranging gear and carry out attack.

While the patrol vessel is engaged in attacking one target, the detection equipment searches the harbor approaches for additional targets as well as continuing to track the target under attack in case the patrol vessel loses contact.

The ideal detection system consisting of Magnetic Loops to seaward, Hydrophones to back up the Loops, and Heralds to back up the Hydrophones is not always practicable, principally due to adverse conditions such as depths of water, state of sea, strong currents, turbulent water, marine growth, or extraneous underwater noises. These natural conditions should be investigated both as to their effects on making the original installation and their bearing on eventual maintenance of the equipment. It frequently happens that the initial installation is made with Sono-Radio Buoys because they may be installed expeditiously, require no connecting cable and are flexible as to depth of the water.

The problem of servicing Sono-Buoys in rough water or anchoring them in heavy seas sometimes prohibits their use even when other considerations favor it. The frequent passage of vessels through a Sono-Buoy line often results in damage to the buoys by collision which makes the maintenance job very difficult.

Magnetic Indicator Loops may not be practicable because of unusual bottom topography or bottom currents which affect them adversely, or excessive depths which result in too much vertical distance between the surface vessel and the Loop cable to give desired detection. Occasionally, circumstances at the shore station prohibit the use of the very sensitive fluxmeters which indicate penetrations of the Loop detection line. Among these are strong magnetic fields from power lines, frequent shocks from shore-based artillery, and the presence of a soil that will not support the concrete pillar on which the fluxmeters rest. Poor line voltage regulation frequently proves to be a troublesome problem. Magnetic minesweepers always put the indicator system out of operation temporarily and frequently damage the equipment when they start "pulsing" so near the Loop system that sufficient time is not given to permit an immediate reduction in sensitivity.

Hydrophones should not be used in great depths where the water pressure is excessive enough to force oil up the cable from the Hydrophone or force a leak in the cable splices. Conditions on the bottom may prohibit the proper placement of the Hydrophone tripods or cause them to be buried under silt after they have been in place a relatively short time.

The Herald is not effective in turbulent or refuse-filled water or in water of mixed salinity such as that encountered near river mouths. It is not capable of withstanding the pressure at great depths and presents the same problem as do Hydrophones in this respect. Since it depends for its operation on the transmission of a sound beam and the reception of the resultant echo from a solid object in the beam's path, the Herald must be located where subaqueous ridges are not interposed between it and navigable waters within range.

A single type of detection device should not be used when it is possible to utilize two or three, because no one type of equipment is capable of detecting all types of targets. If only one type is used, the chances for successful penetration of the harbor by an enemy is greatly increased. Conversely, if three types of devices are used to complement each other, the risk of penetration is minimized.

Unfortunately, many of our advanced base harbors during the war were not adequately protected by detection defenses either because proper equipment was not

available, or if available, was improperly used. If the detection officer at an advanced base were unable to utilize successfully more than one type of equipment, he could establish a double detection line which was difficult to penetrate by planting two lines of Sono-Buoys. The second line was placed 500 yards inboard of the first line, and the buoys in it positioned opposite the midpoints between buoys of the first line which were themselves 1,000 yards apart. By establishing two lines in this manner a sound screen was set up which remained intact even if two adjacent buoys became inoperative. A sonic line can always be penetrated by an absolutely silent target such as a submarine, which drifts in with the tide; or one which has been carefully silenced and is running at a speed below propeller cavitation.

Basic considerations in selecting locations for each piece of detection equipment include the technical limitations of the equipment itself and the distribution of the equipment so that a target is unable to enter the harbor without coming in range of at least one device in each detection line. If this is accomplished, the detection defense is sound strategically and the best possible with present-day equipment.

INITIAL DISCUSSION ON THE THEORY OF HARBOR DETECTION DEFENSE

Referring to Figure I, the basic areas and lines are shown, and will be defined in the text immediately following. In Figures VI to X inclusive, to follow, the same harbor configuration will be used, utilizing various types and quantities of equipment. The officer must not neglect the facts that, first, this is a harbor "made to order", and, second, sufficient equipment is at hand to adequately defend the harbor from a detection viewpoint.

Referring again to Figure I, it will be seen that there are three areas to be considered:

1. The *Protected Harbor Area*
2. The *Hunting Area*
3. The *Detection Area*

There are also three Lines:

1. The *Submarine Danger Line*
2. The *Patrol Line*
3. The *Detection Line*

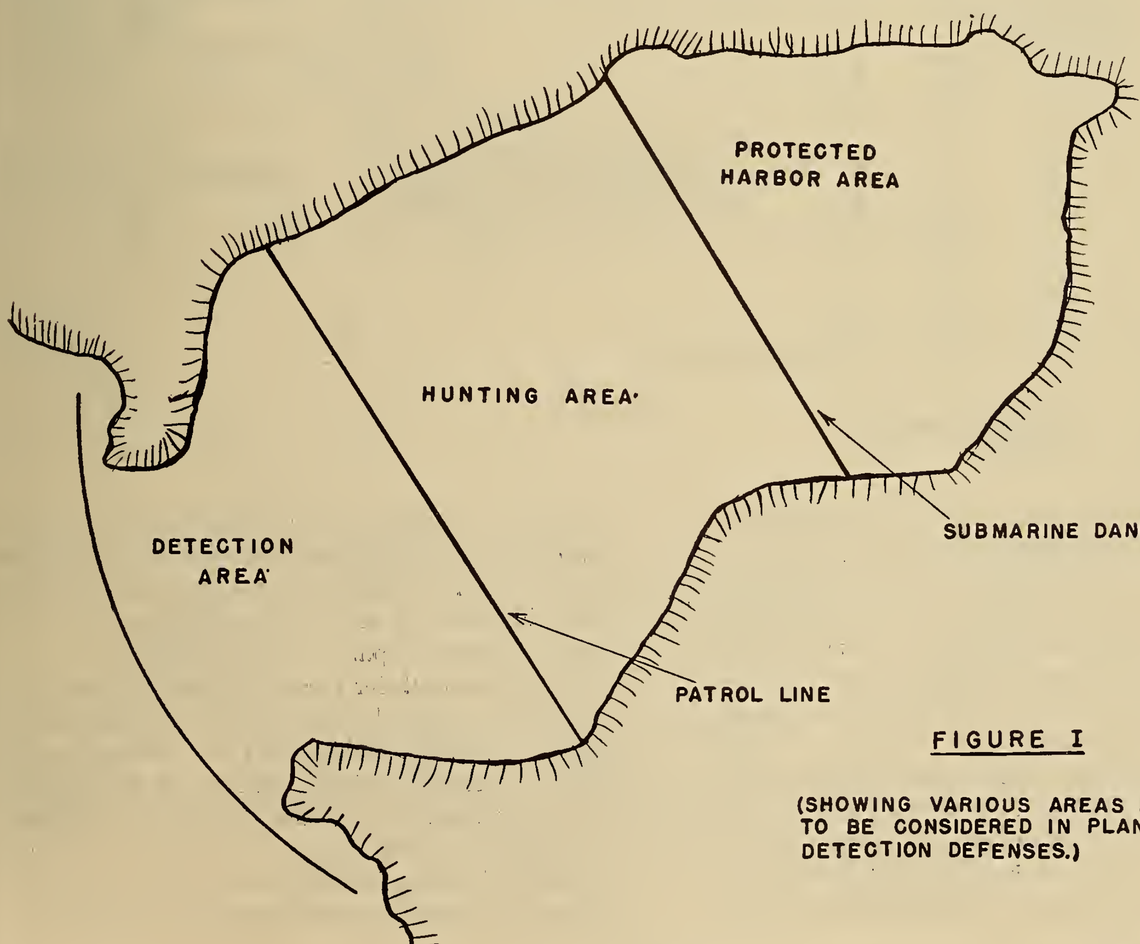


FIGURE I

(SHOWING VARIOUS AREAS AND LINES TO BE CONSIDERED IN PLANNING HARBOR DETECTION DEFENSES.)

It will be noted that in considering the three areas and the three lines above, we are looking seaward from a point in the protection harbor area. This is necessary because, as the first step in planning the use of underwater detection devices, we must first define the protected harbor area and work seaward from that definition.

Defining the extent of the protected harbor area is a function of the configuration of the shore line, the space required for the safe anchorage of a known number of vessels, and the mission of that area in the total strategic consideration.

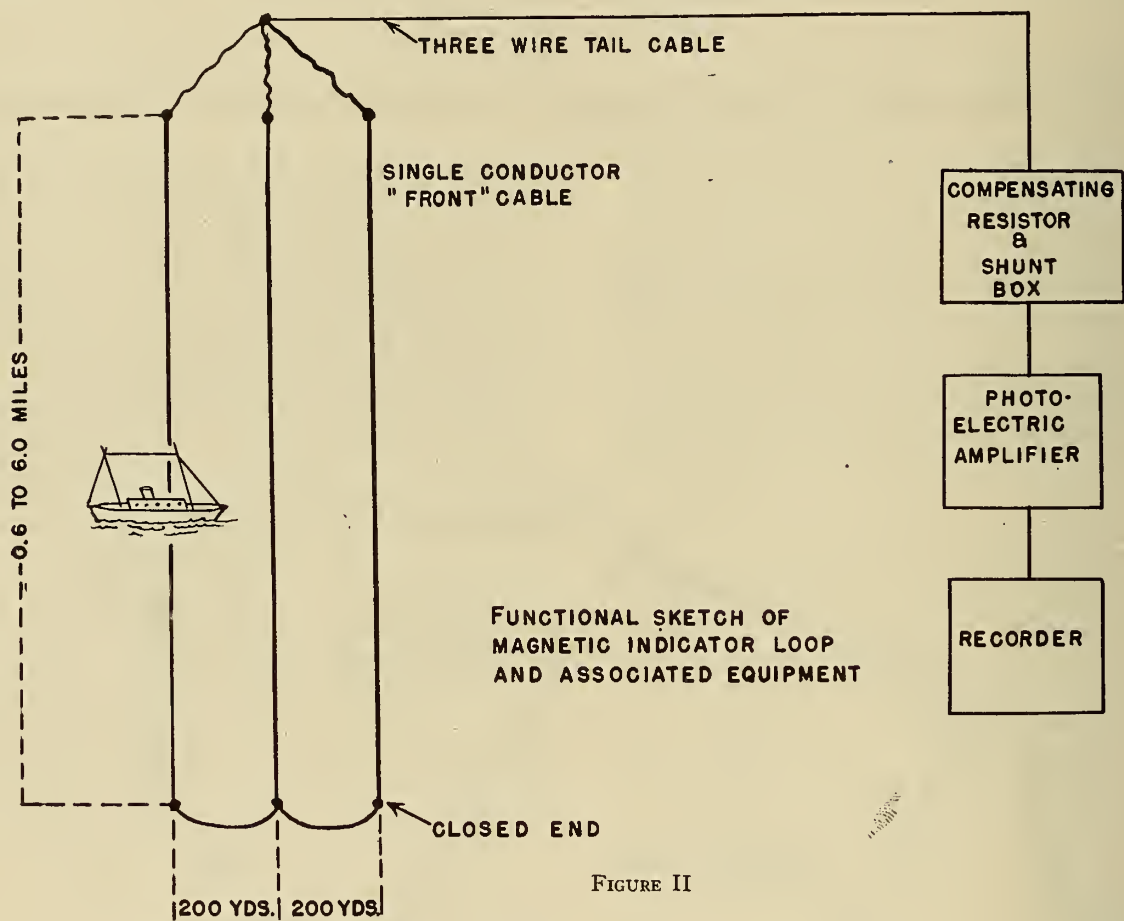


FIGURE II

When the area has been defined, it's seaward limit becomes the submarine danger line and generally is protected by a net or boom defense, and/or a mine field. However, none of these defenses are to be considered infallible, or impenetrable, and therefore the submerged attack, which has its main purpose either torpedoing or mine laying, must be counterattacked before reaching the submarine danger line.

For this reason there must be established the patrol line, along the axis of which the patrol craft lie in readiness to launch the counterattack. This patrol line must be sufficiently seaward of the submarine danger line to allow a hunting area large enough to allow the best tactical coordination of the patrol craft.

Still farther to seaward is the detection line, or the line of initial detection, and between this line and the patrol line is the detection area, or that area in which the penetration is localized and the position of the enemy craft should be detected by the patrol craft.

Theoretically the detection line should be established at a distance from the patrol line equal to the range of a long range torpedo. However, not often is this total distance possible or necessary. Conditions of visibility usually prevent the long-range torpedo attack and thus permit a drawing inward of the detection line.

In any case, the distance the detection line can be from the patrol line may be limited, in a practical sense, by the depth of water beyond the harbor entrance. In other words, the detection line will be established as far to seaward as hydrographic conditions permit.

The limiting depth for fixed detection is assumed to be at 50 fathoms, at which depth the laying or anchoring of equipment becomes difficult and it's effectiveness of operation becomes doubtful, whether it be magnetic, sonic or supersonic in operation. In fact the installation of Magnetic Indicator Loops at great depths will serve only in the detection of the largest vessels, and will be ineffective in detecting small (midget) submarines.

Locating the detection line for effective defense detection consequently becomes a problem of compromises with existing hydrographic conditions versus the location of other defenses and activities of the harbor.

The detection line, defined, is that line of underwater detection defense at which the presence of enemy vessels must first become known in order to warn all other defensive agencies of impending attack. The value of this initial warning cannot be overemphasized.

The detection line should be composed of the most effective type of fixed detection equipment for the underwater conditions of the locality. The local hydrographic conditions will always be the dictating factor in this respect and it must be remembered that there are no standard rules for the use of any of the underwater sound detection units.

The Magnetic Indicator Loop is considered at present to be the most effective type of detector for the first line unless the depth of water makes its use unwise.

Where depths are excessive along the chosen detection line it may be possible to establish that line by the installation of Sono-Radio-Buoys, or of Heralds in anchorable soundings behind the line, using their listening ranges to extend the defense seaward. In this case the detection line is *the common* seaward tangent of the sonic range of the detection units.

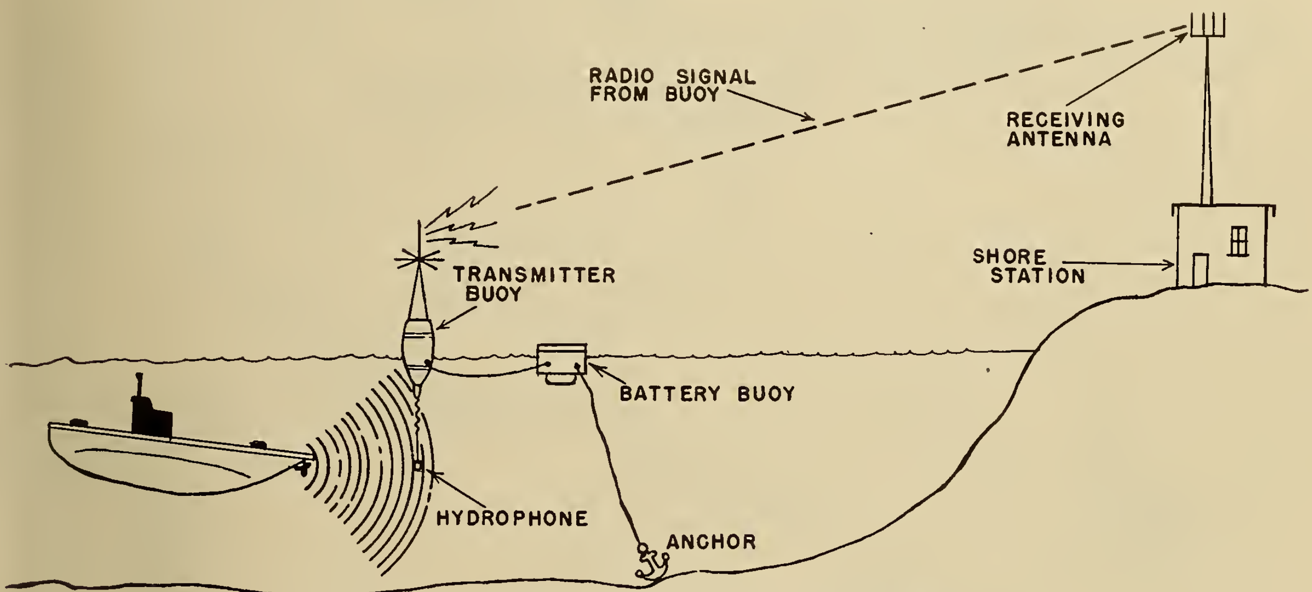


Figure III.—Functional sketch of operation of Sono-Radio Buoy transmitting sound of submarine's propellers to shore

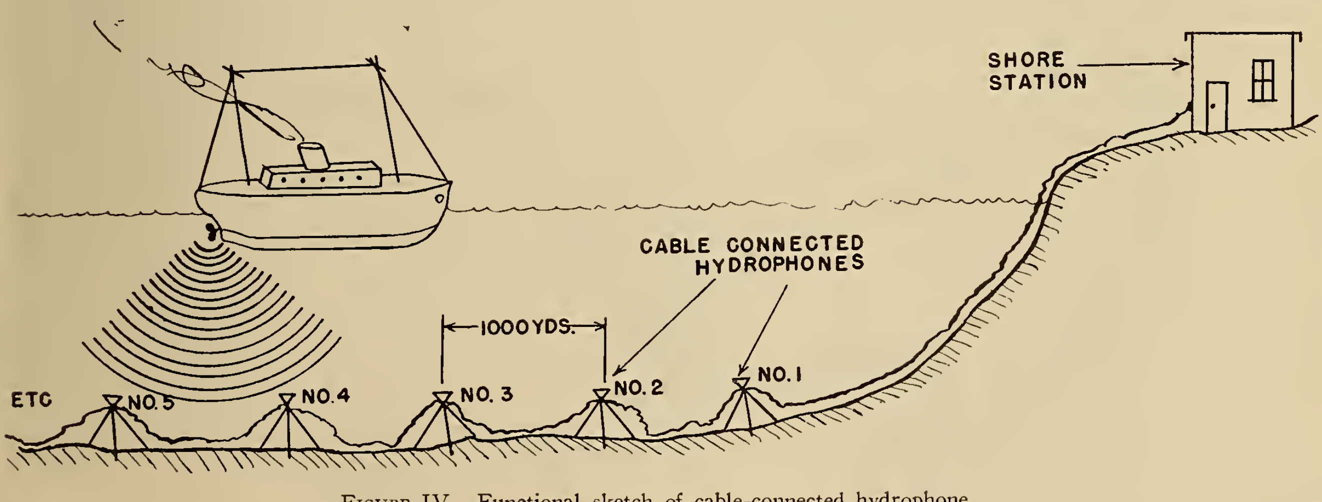


Figure IV.—Functional sketch of cable-connected hydrophone system transmitting sound of ship's propellers to shore station.

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Section VI
Section VII
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Section IX

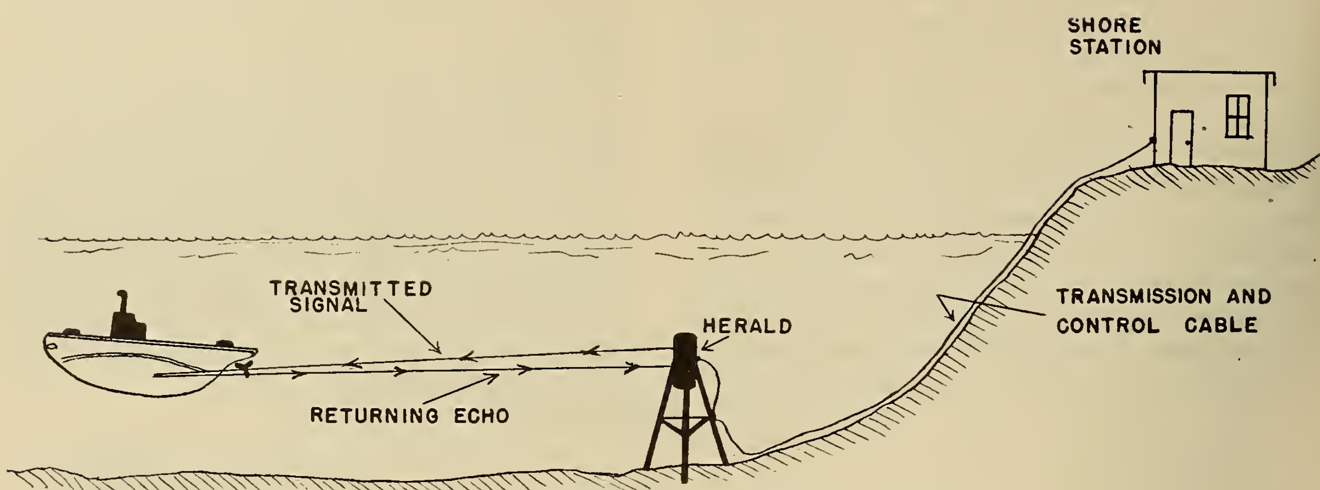

Figure V.—Functional sketch of operation of a herald, showing transmitted signal returning from submarine.

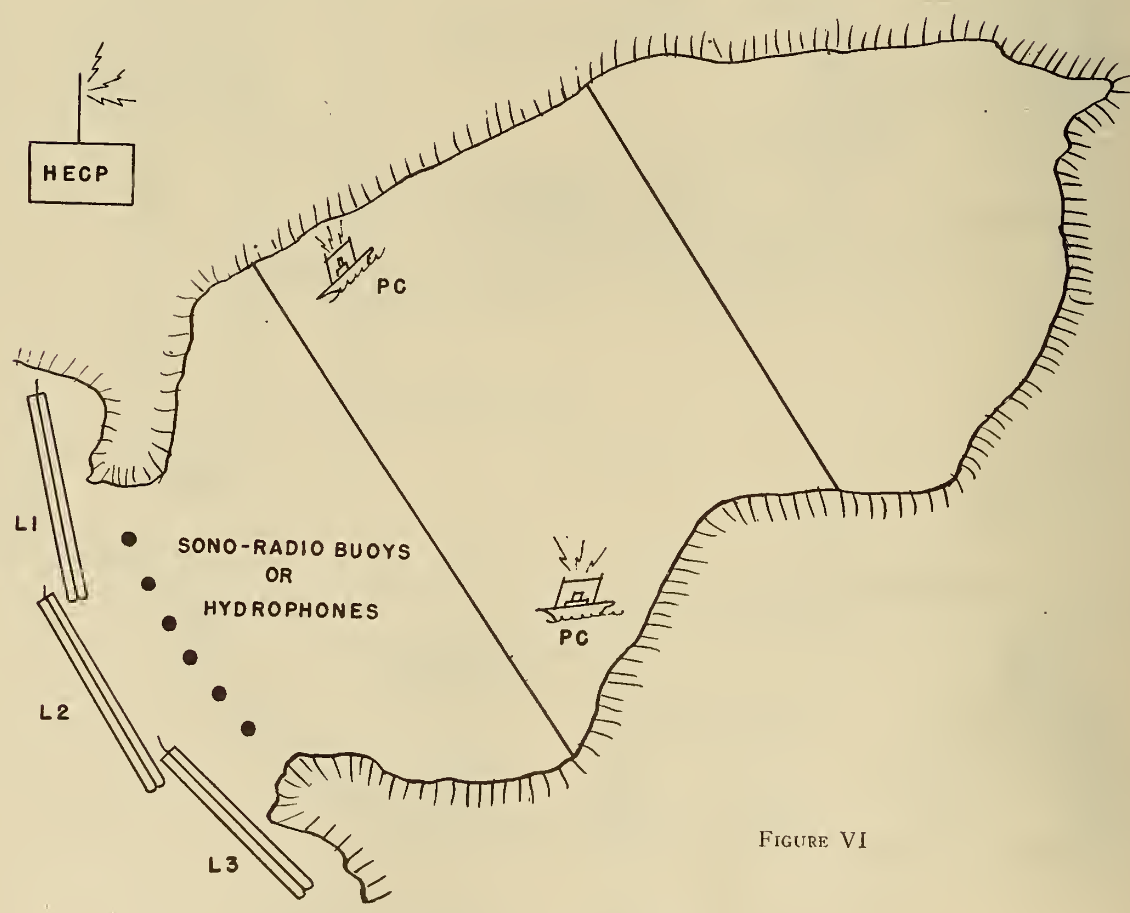

Figure VI

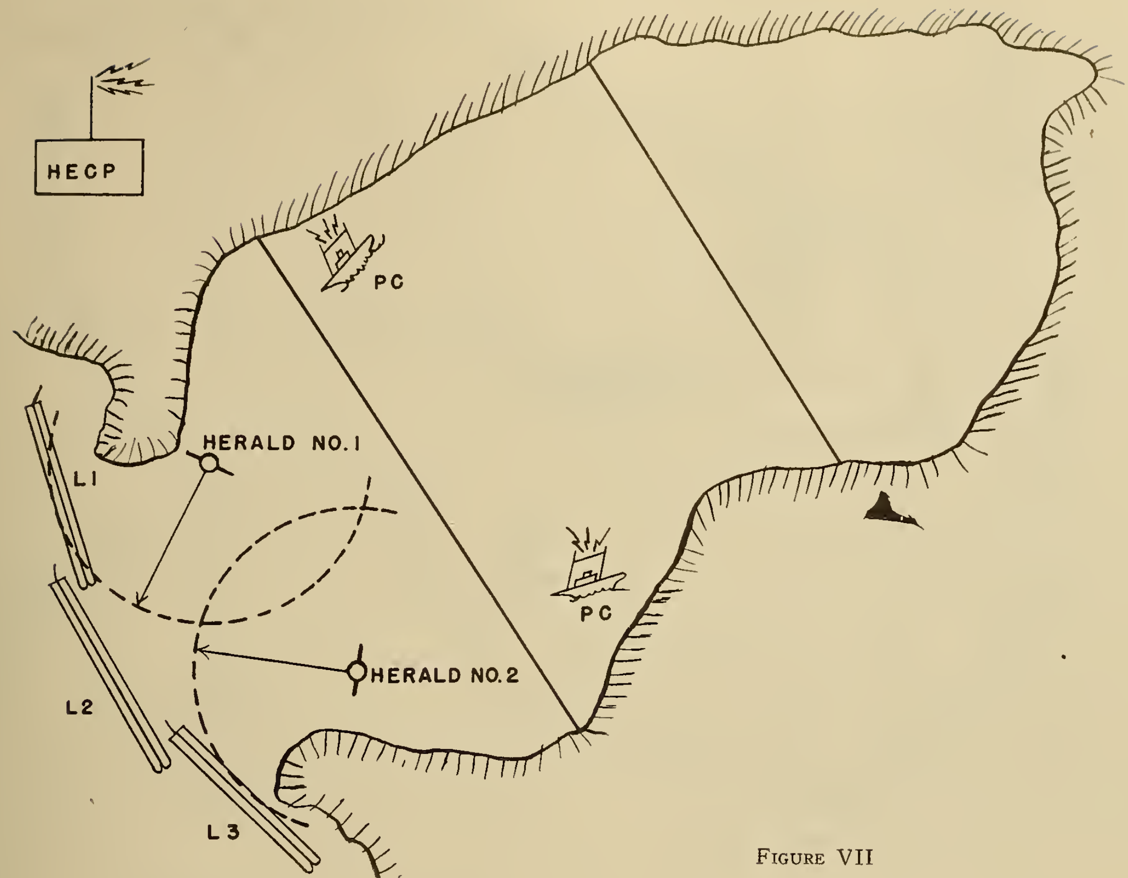

Figure VII

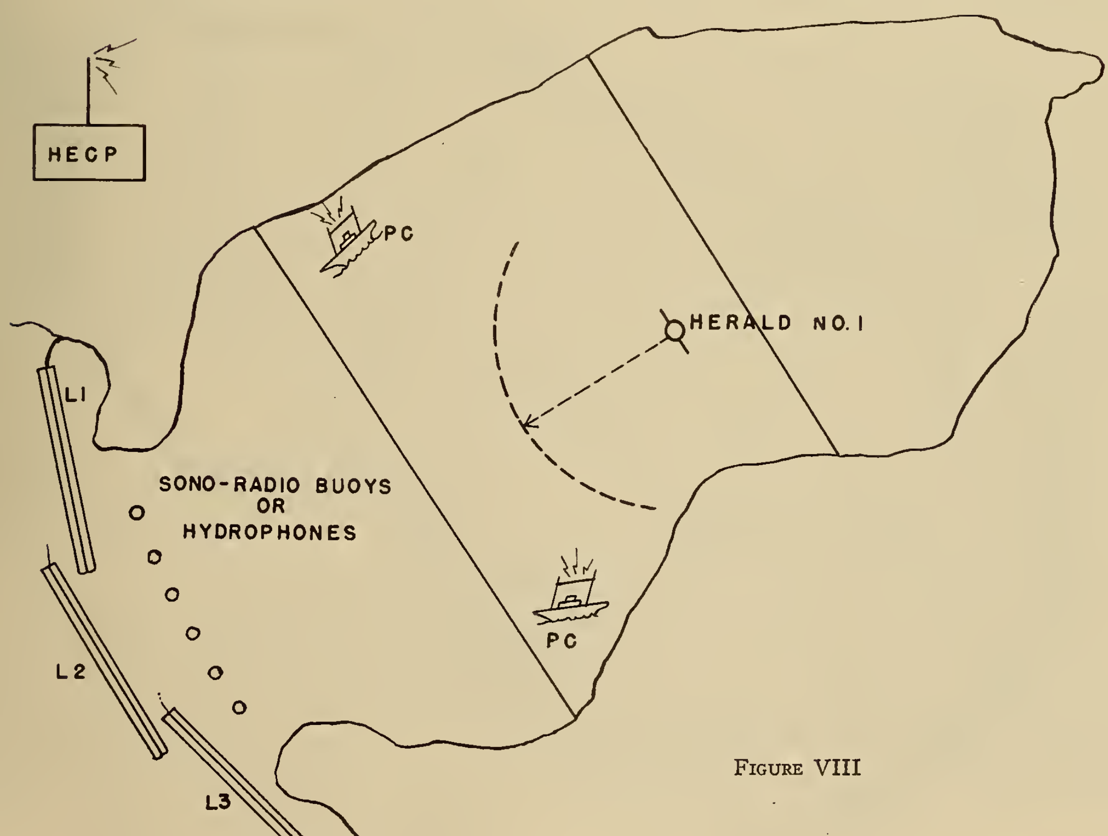

Figure VIII

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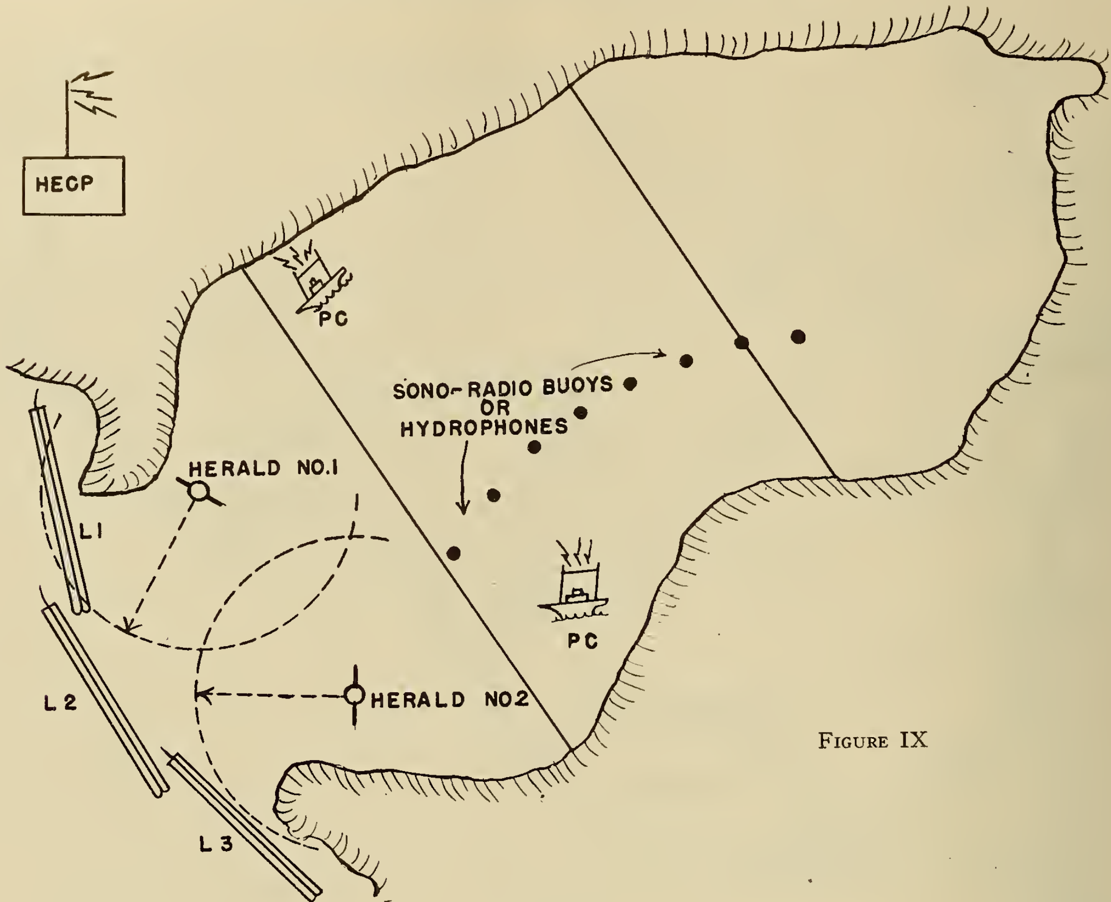


Figure IX

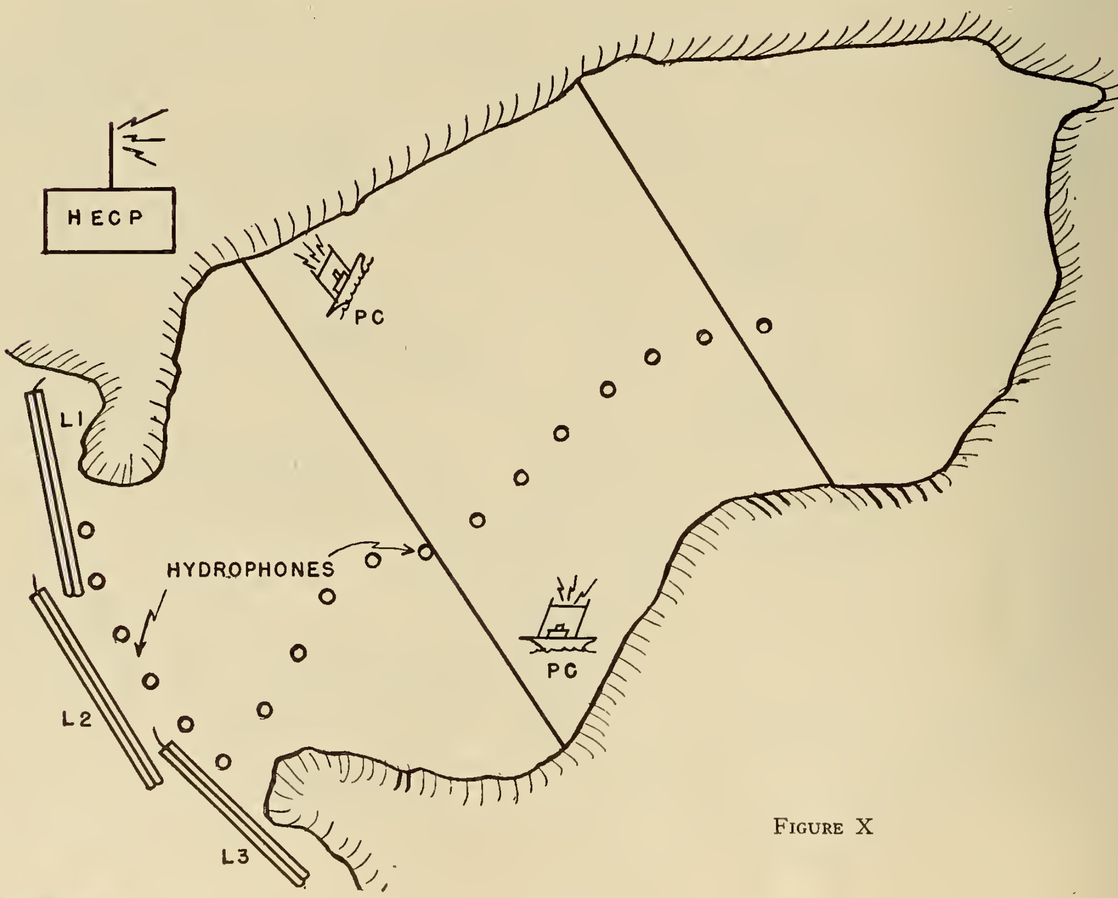


Figure X

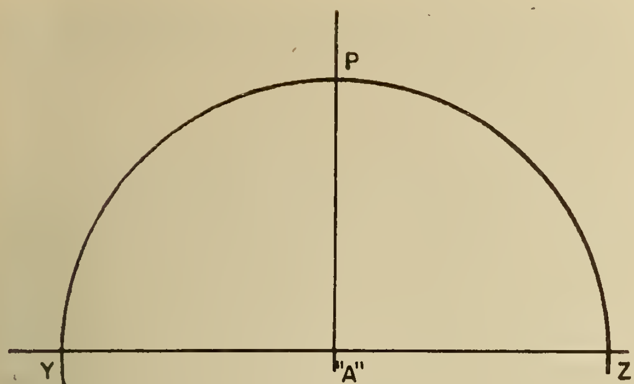


FIGURE XI

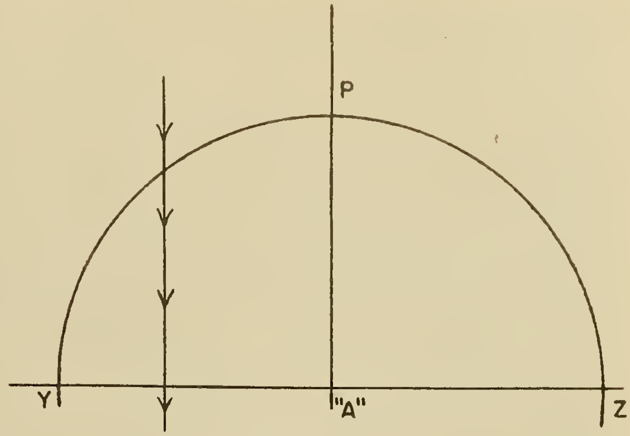


FIGURE XII

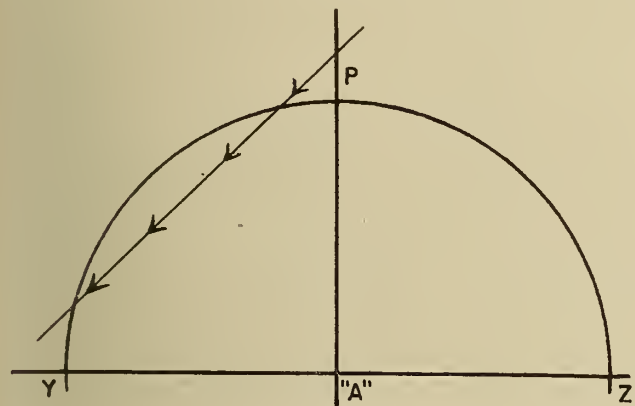


FIGURE XIII

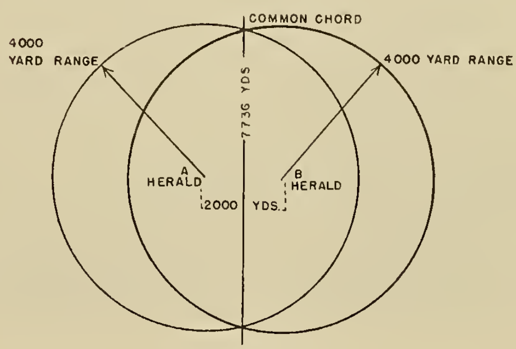


FIGURE XIV

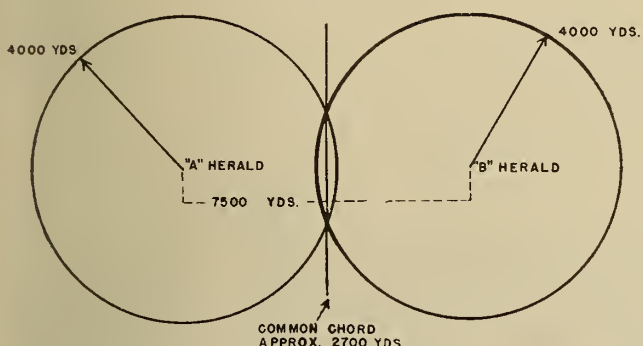


FIGURE XV

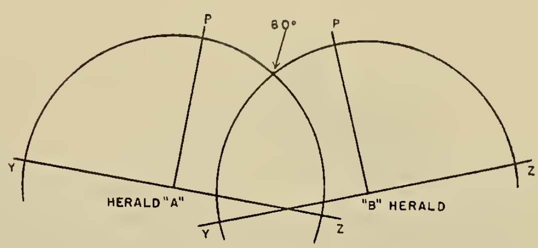


FIGURE XVI

THE SONO-RADIO-BUOY

In planning the use of Sono-Radio-Buoys, their strategic value must be correlated with their limitations of range and their surface visibility.

Fundamentally, the Sono-Radio-Buoy comprises a buoy barrel containing a medium-powered frequency-modulated transmitter, an antenna for transmission of the radio wave, a suspended crystal hydrophone, together with a separate battery float and anchor.

In practice, the buoys are generally spaced over the detection area, immediately behind the supplementing the Loops for the purpose of localizing the point at which one of the Loops has been crossed. The buoys may be spaced not over 1,000 yards apart in quantities depending on the number of buoys available and the length of the detection line. Obviously, the more closely the buoys are brought together, within reason, the more localizing influence they will exert, although the accomplished operator will, through proper integration of the amount of sound being received on adjacent buoys, be able to determine the position of the penetration with surprising accuracy.

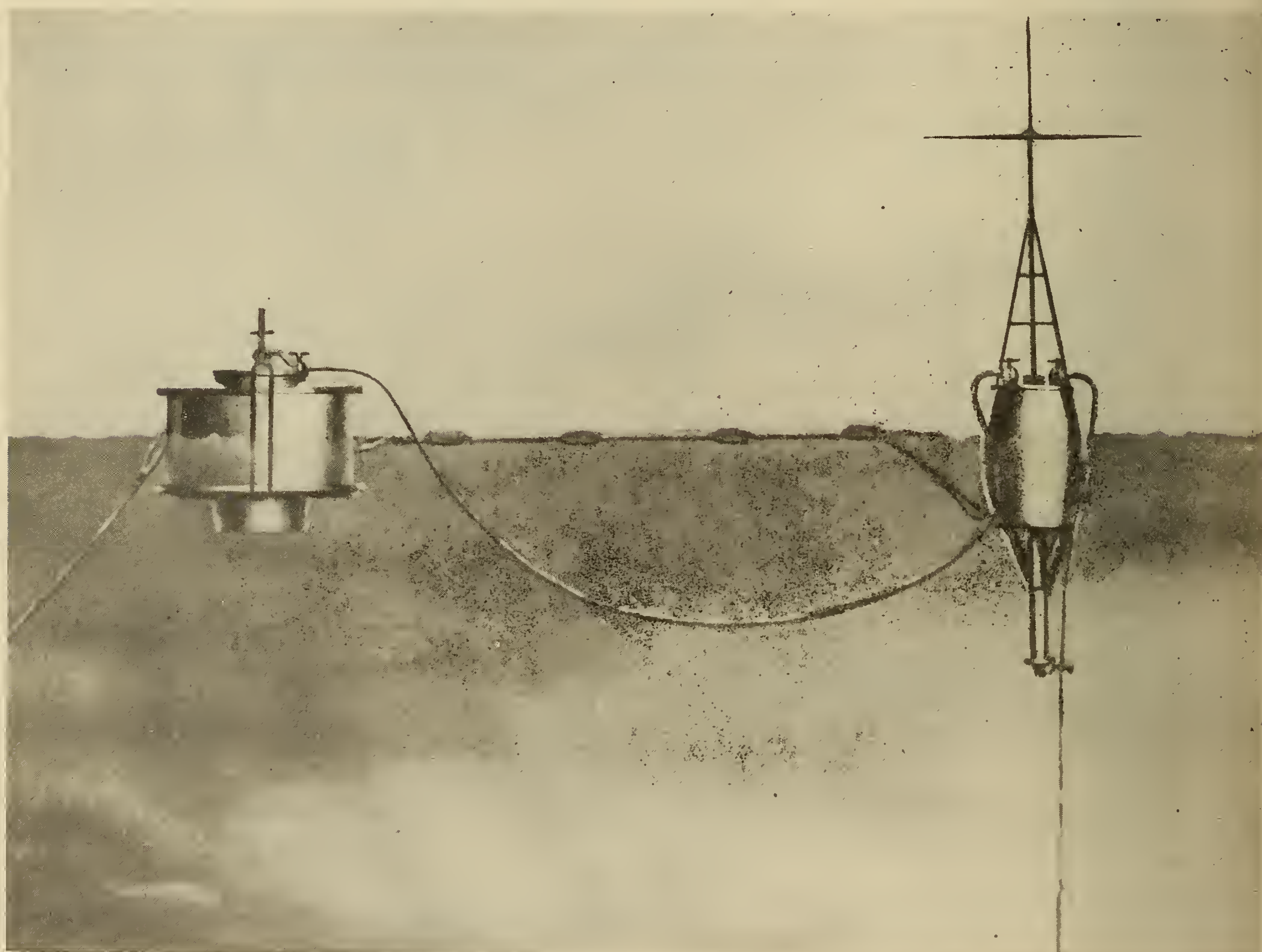
[redacted]

The Sono-Radio-Buoy can be of great strategic value in establishing a "screening" line in as short a time as possible. Obviously the buoy can be put into complete operation in a much shorter time than any of the other underwater detection systems, and, therefore, can be utilized to establish this "screening" line, or a temporary line of initial detection, until such time as the Loops, Heralds, and Cable-Connected Hydrophones can be installed. Tests have proved that a buoy can be placed in complete operation within twelve minutes of the arrival of the buoy boat in the desired location.

Great thought must be given to the permanent placement of buoys, particularly if it is desired to use them in a well traveled channel where the night-time mortality rate of the buoy is apt to be high due to being run down in the dark by passing ships. In many cases, the use of Cable-Connected Hydrophones is indicated. If not available, then the buoy must be placed most judiciously in order to preserve it from injury.

Having a normal transmission range, in some localities, of as much as 10 miles, the buoy has been used most effectively in "monitoring" anchorages in outlying islands as guards against possible enemy penetration.

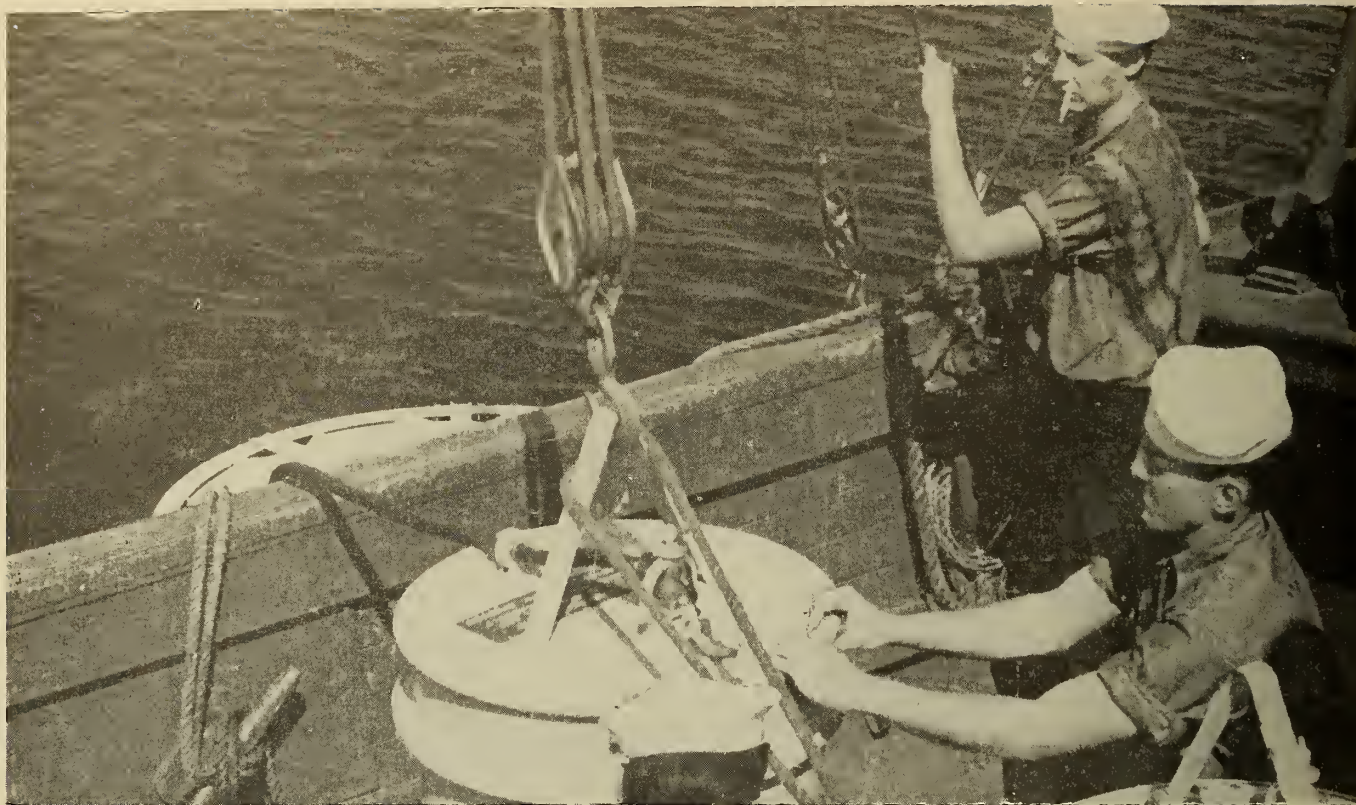
The tactical value of the buoy, as in the case of the Magnetic Indicator Loop, is directly proportional to the diligence and intelligence of the operating force, and too much stress cannot be placed on the need of that force being well instructed in the various sounds, such as propeller, engine, and hull noises of vessels, and other background sources such as fish, buoy, bottom sounds and water perturbation.



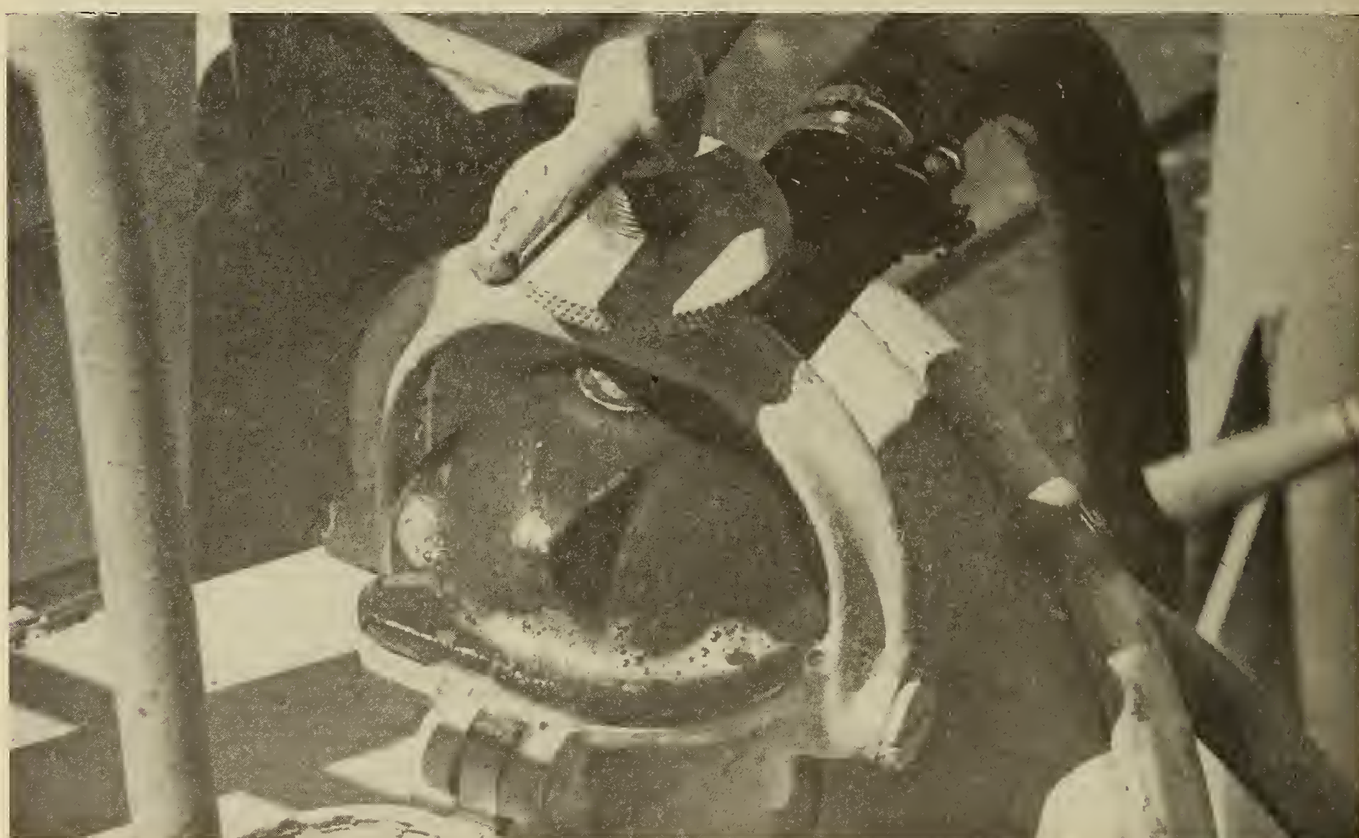
This is the M–3 Sono-Buoy after the installation is completed and with the unit in operation.

A Sono-Buoy unit consists of many parts. Before installation personnel shove off from the dock, they should check to see that they have everything needed. By assembling the various parts of the unit line, little difficulty will be experienced in planting the unit hurriedly and expertly.

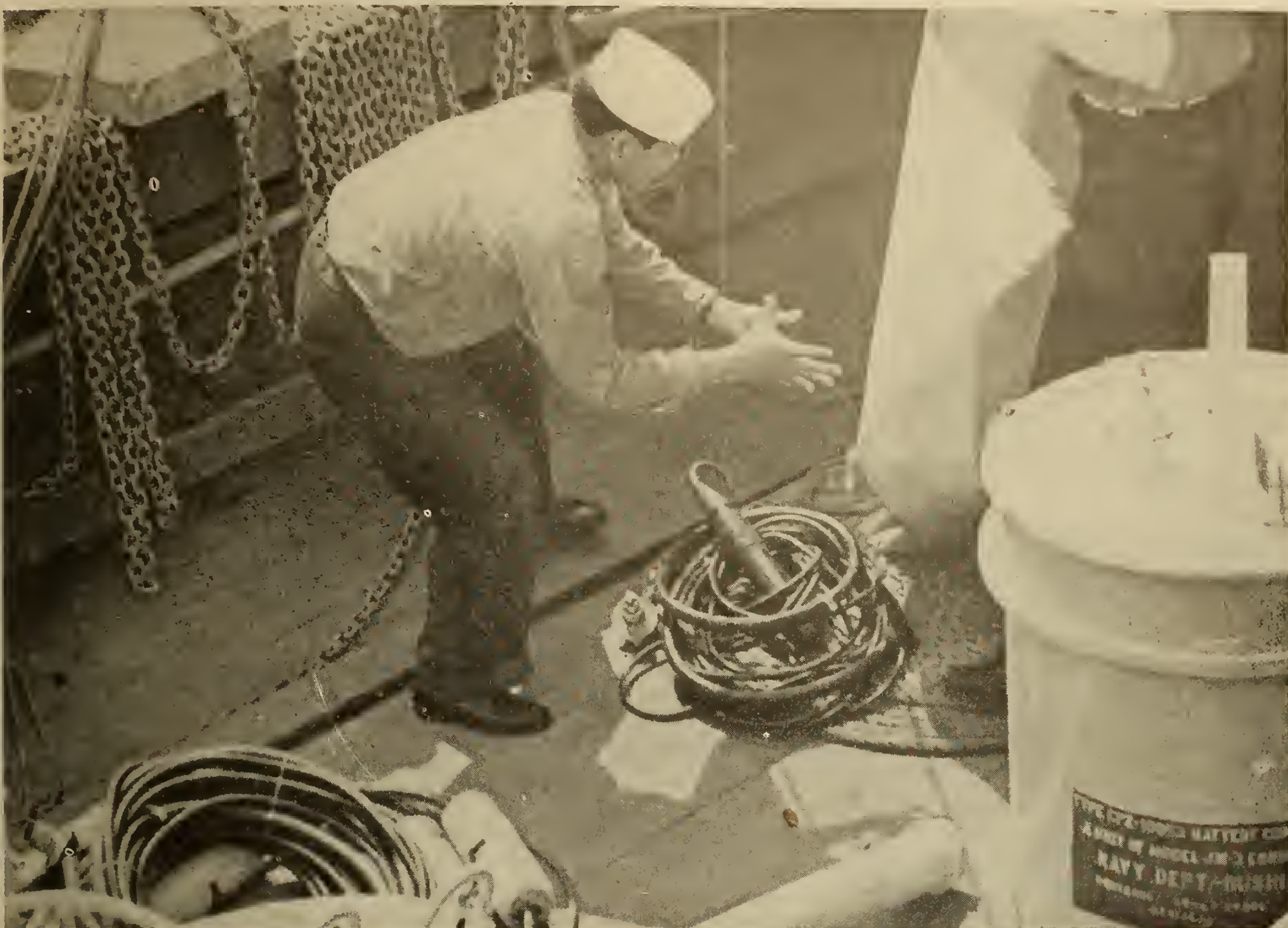
The battery raft section of the Sono-Buoy unit is almost ready to be lowered over the side.



After placing the battery raft in the water, personnel prepare to place the battery container over the side and into the raft where it will be locked.



After the battery cable has been connected to the transmitter barrel, the application of soapy water will reveal if any air is escaping.



The Sono-Buoy hydrophone should be wrapped either in canvas or in some other type of cover until it is ready to be placed in the water. Sun can be very damaging if the hydrophone is exposed.

INFORMATION ON IMPROVEMENTS IN OPERATION OF SONO-RADIO-BUOYS

Figure 4–1 illustrates what is considered to be the most reliable method of installing this equipment. The particular details to be noted are as follows:

Thimbles are used at the ends of the tie rope. The original recommendations were to cover the ends of the tie rope with rubber hose to eliminate the transmission of noise from the battery buoy to the transmitter. This rubber hose has been reported to cut through very rapidly in rough water, thereby causing the wire rope to bear directly on the buoy beckets and to fail prematurely. The use of thimbles may introduce a slight clanking noise in the hydrophone, but this has not been found to be serious. The noise may be reduced by serving the transmitter buoy becket with one or two layers of marlin or by wedging a short piece of rubber hose into the thimble outside of the becket.

It is recommended that the tie rope be made in duplicate where rough water prevails. This is a form of insurance reported to be effective in guarding against occasional loose wire rope clips, rusting of the wire rope and other causes of premature failure. A very reliable tie rope made of ⅜-inch chain has been tried but is not generally recommended because of the excessive volume of floats required.

The ends of the wire rope are served with small diameter wire to prevent fraying, and then taped to cover all sharp edges. It has been reported that the battery connecting cable between the transmitter and battery buoys has on occasions rubbed against the ends of the wire rope to such an extent that the rubber jacket on the battery cable was damaged.

Floats are secured to the tie rope to maintain the tie rope on the surface. This addition to the Sono-Radio-Buoy system, after extensive field trial, has proved to be very essential to every installation. The floats recommended are constructed of commercial two by four white pine lumber approximately 16 inches long. Each float will adequately float four feet of ½-inch wire rope. If a double tie rope or a chain tie rope is used, the volume of the floats must be made correspondingly larger. Twenty wood floats will be supplied with each new Sono-Radio-Buoy but because of their simple con-

[redacted]

struction none will be maintained in stock.

The thimbles secured at the ends of the tie rope should be spliced in, if time is available. A convenient procedure is to prepare several tie ropes on shore, splice the thimbles in place and secure the tie ropes in the operating equipment with shackles. Recommended lengths of tie ropes and battery cables are shown in the following table.

It is recommended that the stainless steel bands on the CBD–51031 hydrophone be either painted over with black paint or be removed and the seams between the cap and case and between the cap and cable be taped with several layers of black rubber tape. Reports have been received from the tropics that certain species of fish are attracted by the bright bands and that they have on occasions damaged the rubber case. Taping the hydrophone has the additional advantage that it definitely eliminates the possibility of leaks in the upper chamber of the hydrophone. The hydrophones in production at the end of the war had the upper chamber filled with a wax and the aforementioned seams taped with rubber tape. The following taping procedure was being followed by the contractor:

(1) Remove all metal bands except the band which clamps the hydrophone cap to the cable.

(2) Roughen the rubber cover and cap of the hydrophone with a rasp or coarse sandpaper to a distance of 1½ inches each side of the wire clamping bands.

(3) Clean the roughened surface with a greaseless cleaning fluid such as carbon tetrachloride.

(4) Apply rubber cement over the cleaned surface, rubbing it well into the surface with the fingers.

(5) Tape with three layers of a good grade of rubber tape. Start taping at the seam, working out and then back, carrying each layer farther out over the cover and cap. This tape should be handled like rubber tape and should be stretched to approximately 50 percent of its normal width and applied with 50 percent overlap.

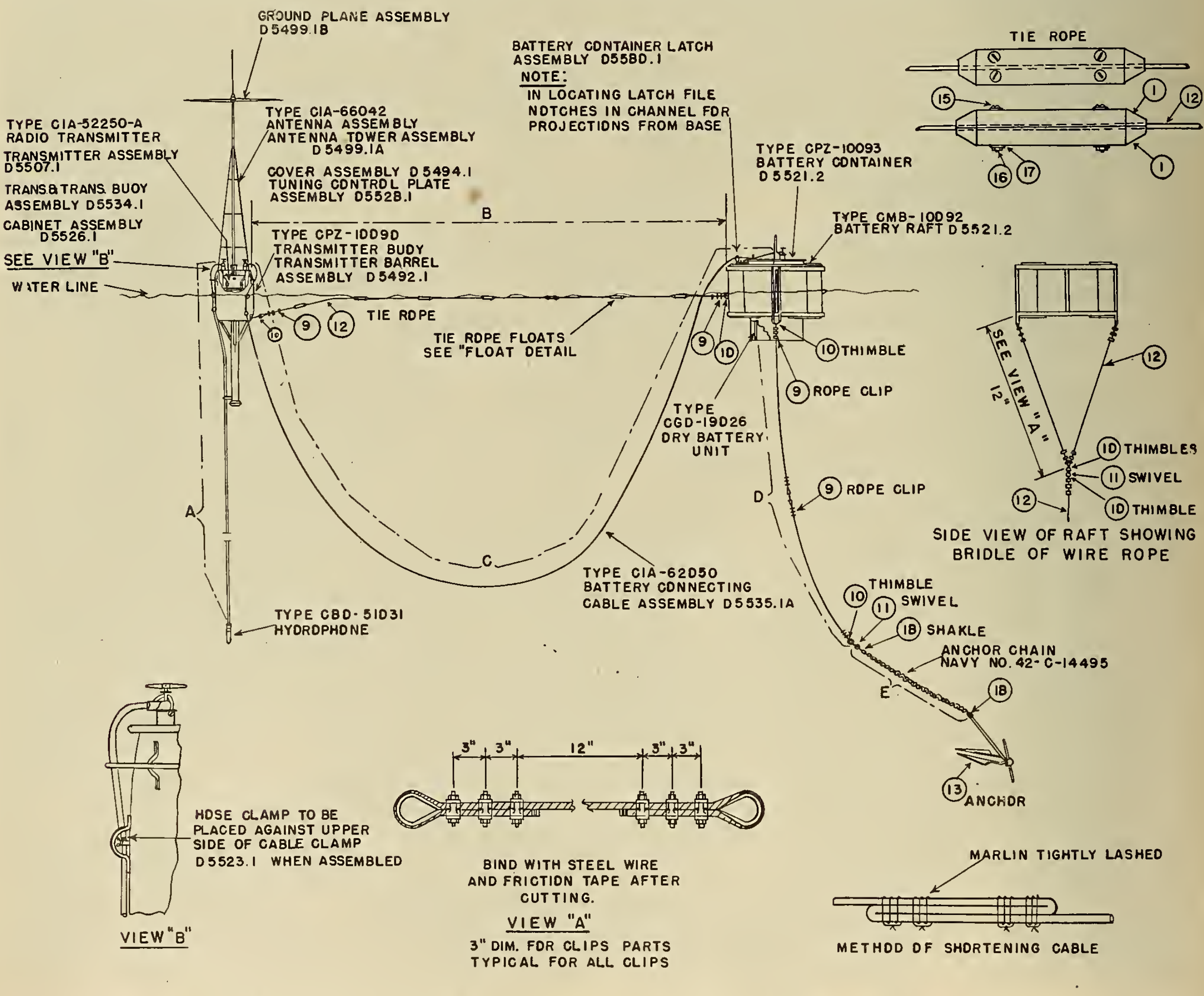


FIGURE 4–1 MODEL JM-4 RADIO TRANSMITTING EQUIPMENT INSTALLATION.

(6) Roughen the rubber cap to a distance 1½ inches on the cap side of the metal band. Roughen the cable to a distance two inches away from the hydrophone.

(7) Apply rubber cement over the roughened surface and tape as above, building up a tapered joint between the rubber cap and the cable.

(8) Paint the identification information normally stamped on the metal bands, on the rubber cap or cover. The paint used should be of a dark color, preferably maroon.

A heavy concrete block type of anchor is recommended. The Danforth type anchor is supplied with the Sono-Radio-Buoys to provide immediate means for installing this equipment, and should not be relied upon for permanent installation. Because of the great variety of conditions encountered, it is not considered desirable to specify a particular size and weight of anchor but rather to recommend that the judgment of local buoy handling experience be solicited. If in doubt and material and handling facilities are available, 3,000-pound concrete blocks should be cast and installed. If lifting facilities for this weight of anchor are not available, a 500-pound concrete block secured to the anchor line some distance from the Danforth anchor can be used to greatly improve the holding power of this anchor. Concrete anchors will not be supplied with the Sono-Radio-Buoys because of their large weight and size and because they can be readily constructed in the field.

Particular lengths of hydrophone cable, tie rope battery connecting cable, chain anchor line, and wire rope anchor line are recommended. These lengths were established by calculations based on the buoyancy of the equipment, the weight of the wire rope and chain and on the knowledge of how the units of the equipment rotate with respect to each other during a change of tide. If currents above four knots are encountered, the safest procedure will be to use wire rope throughout and to experiment with the use of chain for the lower parts of the anchor line.

The JM series Sono-Radio-Buoys were designed for operation in water depths up to 100 fathoms, the determining factor being the reserve buoyancy provided in the battery buoy for supporting an anchor line. Should it be desired to anchor in water depths in excess of 100 fathoms, the scope of the wire rope mooring line should be reduced to 2–1 and the buoyancy of the battery buoy (raft) should be increased by one of the following methods:

(1) Weld two sealed drums to the sides of the battery buoy diametrically opposite from each other displaced 90° from the beckets to which the bridle is secured. Two drums of 50-gallon capacity each should permit anchoring in depths of 300 fathoms assuming that water current of the order of two knots will be encountered. The drums should be welded so as to be in a vertical position in operation and so that their vertical centers are approximately in line with the vertical center of the battery buoy. A metal rod wrapped around one of the buoys having its ends welded to the battery buoy can serve as the tie point for the tie rope.

(2) Weld two battery buoys to each other, side by side, using four lengths of ¼ by 2-inch iron tie members. Weld two beckets, one to each of the two bottom angle iron tie members, the beckets to be located so that one end of the oblong assembly will nose into the current and so that the weight of a loaded battery container in the trailing buoy will approximately balance the weight and drag of the anchor line on the beckets. This assembly should operate satisfactorily in water depths up to 300 fathoms.

(3) For extreme depths, improvise a larger battery buoy on which the battery container must be secured. It should be realized, however, that at these depths it may be impracticable to maintain the recommended spacing (1,000 yards) of adjacent Sono-Radio-Buoys without fouling the lines of adjacent buoys.

Model JM-4 radio transmitting equipment table of tie rope and cable lengths in feet

Low water depth	Hydrophone cable "A"	Tie rope "B"	Tie rope floats	Battery cable "C"	½ inch anchor rope "D"	⅜ inch anchor chain "E"
20	15	20	5	25	0	100
50	46	30	8	Full	0	200
75	Full	30	8	Full	0	300
100	Full	30	8	Full	0	400
150	Full	30	8	Full	120	480
200	Full	30	8	Full	160	640
300	Full	30	8	Full	240	960
400	Full	30	8	Full	1,600	0
500	Full	30	8	Full	2,000	0
600	Full	30	8	Full	2,400	0
700	Full	30	8	Full	2,800	0

MODIFIED SONO-BUOYS

Sono-Buoy sea units can be redesigned to operate in locations that tax the mechanical strength of the moorings of the JM–4 equipment.

The stronger design is made by mounting the present equipment on a Mark 2 net buoy rebuilt to act as a combination battery raft and transmitter buoy.

First, the net buoy is set up on end and the base is filled with enough concrete to make it float at the desired

depth in the water. The amount of concrete used will vary with the length and size of the anchoring chain. Approximately 6,900 pounds of concrete was used in the base of the first buoy of this type.

A 30-foot bridle for the buoy is made from wire rope with a diameter of one inch or larger. The bridle is hinged to the buoy at a point from the bottom of the buoy equal to one-half the draft of the buoy. If this is done, the buoy will ride in a vertical position despite any water current there may be in the anchoring area. The anchor can be made of concrete. One inch chain is ideal for attaching the buoy bridle to the anchor.

The battery and the battery barrel are mounted in a well in the top of the buoy. The well is made from rolled sheet steel and welded in place on the buoy so that the top of the well is flush with the deck of the buoy. Clamps are made and welded to the buoy to hold the battery barrel in place when the unit is anchored in a rough sea.

The transmitter is mounted in a small water-tight box. The box is made from light sheet steel, and the antenna and ground plane are attached to the top of the box. This box is bolted to an upright that supports the transmitter about five feet above the deck of the buoy. The upright is welded to one side of the buoy so that it does not interfere with the changing of batteries. A short battery cable is used to connect the transmitter to the battery, and the microphone cable is led from the transmitter into the water through a three-inch pipe welded to the side of the buoy. The weight of the finished buoy will be approximately seven tons.

Once this unit is built and planted, it is very easy to maintain. One man can remove the transmitter if it needs servicing. Tangled up units are eliminated, and there are no tie cables between transmitter barrel and battery raft to break. The unit is large enough to hold two men when working on the buoy, and it will support long lengths of chain when anchored in deep water. The unit will ride in rough seas with little inherent noise.

A watchstander tunes his RBF–3 Sono-Buoy receiver. This particular model, which incorporates either push-button or automatic tuning, is the last word in Sono-Buoy receivers.

SONO-RADIO-BUOY RECEIVERS

Two types of special receivers are used for Sono-Radio-Buoy reception. One of them, Model RBF–1, consists of a rack and panel assembly of 10 receiver units, a common power supply, and a switching unit. Each of the receivers will be tuned to a particular buoy, and the switching mechanism will automatically connect the different receivers to the common amplifier system. Because of the greater weight of the Model RBF–1 receiver and its greater power requirements (600 watts), the use of this receiver will be restricted to well established activities.

The second receiver, Model RBF–3, consists of a single receiver to which a mechanical tuner is attached to accomplish the same functions as the Model RBF–1. This receiver is considerably more portable.

A watchstander tunes in RBF–1 Sono-Buoy receiver.

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SAFETY PRECAUTIONS

The importance of observing the utmost caution in handling Sono-Radio-Buoy battery containers cannot be overemphasized.

It must be realized that installation of the breather valves and gastight housing and fuse assemblies is no absolute guarantee that the hazard of battery container explosion is entirely eliminated. It is urged that the following safety measures be observed in addition to the precautions being followed in accordance with existing instructions:

(1) Remove the valve core from the valve stem immediately after the battery container has been tested for air leaks. Then install the breather valve.

(2) When in changing batteries the battery container is taken aboard the servicing boat, first and prior to disconnecting the battery cable, unclamp and remove the cover.

(3) In working with the battery containers, never smoke or permit open flames in the immediate vicinity. Always keep your head and body clear of the area immediately above the battery container cover.

ICING

Operators in some of the harbor detection stations in the far North were puzzled at the intermittent operation of their Sono-Buoys. During the day all was well and the buoys transmitted normally but at night they would, one by one, mysteriously leave the air. It was found that heavy icing caused the transmitter buoy to lay on its side, grounding the antenna and not allowing energy to get into the air.

Considerable damage can be done to the buoys by heavy icing, and so far as is known there isn't much that can be done about it except to put in Cable-Connected Hydrophones or wish for warmer weather.

A Sono-Buoy is not supposed to look like the one shown in this picture, but Aleutian detection personnel can verify that ice can change a normal appearance with very little trouble.

THE MAGNETIC INDICATOR LOOP

When considering the detection line, or the initial line of detection, it is right that the Magnetic Indicator Loop should be given first thought. The Loop is the most dependable and flexible device yet found for underwater detection. It offers few problems and presents little difficulty in maintenance and repair.

The Loop is a very sensitive detection device when properly laid and operated. The distortion of the earth's magnetic field by a metal object crossing the cable causes magnetic unbalance between the two areas enclosed by the cable, generating minute currents which are indicated by a sensitive recording fluxmeter galvanometer in the shore station.

Tactically, the Loop's flexibility is of great advantage in that it can be used to detection-defend stretches of water up to six miles in width. In actual practice, Loops have been laid as short as 0.6 miles and as long as 6.3 miles. The average length is between 2.0 and 3.0 miles,

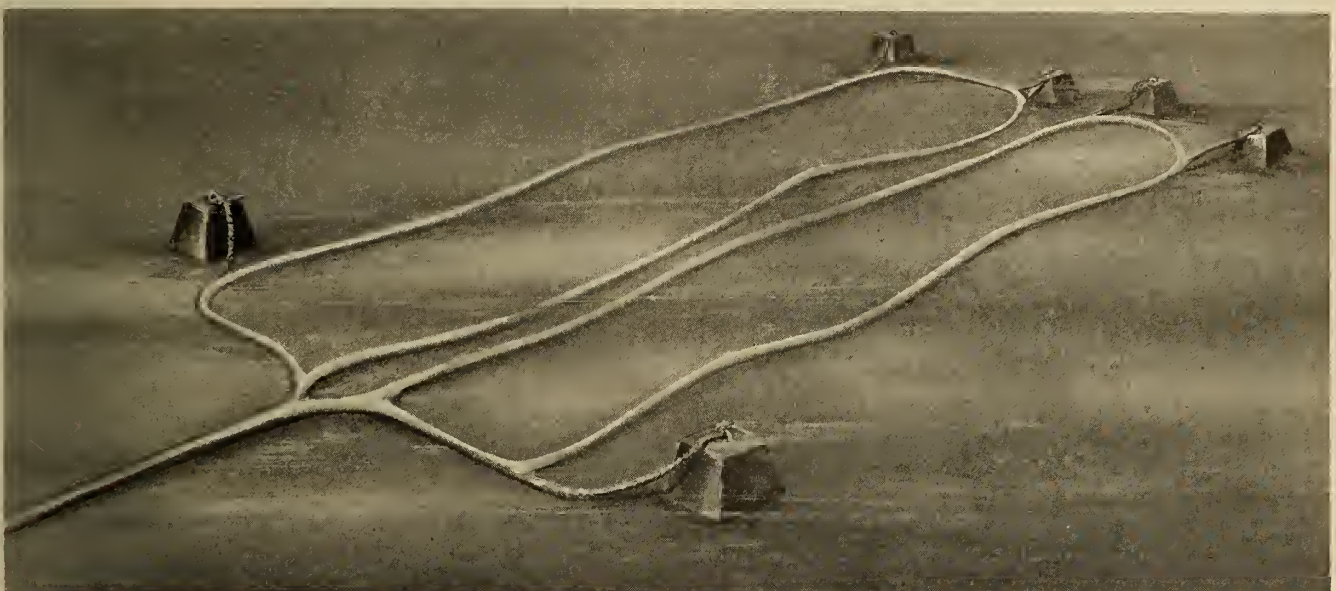
and the length should be kept as short as possible, within reason, and in keeping with the availability of fluxmeters, for the obvious reason that the shorter the Loop the more localized is the determination of the act of penetration. Due to reduction in background, short Loops can be operated at higher sensitivities.

Two hundred yard spacing of the legs is considered standard and was determined upon because that is the average length of the large vessels passing over the Loop. In some instances, closer spacing is indicated, particularly in channels, due to the constricting influence of marker buoys, or where the Loop is to be laid in shallow water expressly for the detection of small craft and/or midget submarines.

If called upon to decide the location for the Loop, it must be kept in mind that while the Loops must be of very evident and concrete warning.

In one case on record, the operators spent more than eight minutes in trying to decipher a very evident signature. In the meantime, the midget submarine had released its torpedoes within the harbor.

In the initial tactical planning for the defense of the total harbor, consideration must be given to all phases of the strategic value of the harbor. The establishment of the initial line of detection must be coordinated with existing or planned minefields; where a minefield is considered 100 percent efficient, or impenetrable, it is obviously useless to lay a Loop behind it, although it might be tactically wise to lay one to seaward, particularly in the case of controlled mines. Advantage must also be taken of existing shoals and islands off the harbor entrance in order to save materials and time.



The Multi-turn Loop after installation has been completed.

the greatest strategic value in terms of area covered, consistent with materials at hand, it should be laid on the bottom as flat as possible, and in sand, if possible, so that it will bury itself rapidly and thus acquire stability in the shortest possible time. Care must be exercised in not running the Loop cables over sharp, rocky prominences because the cable catenaries are moved violently by sea action. The tail cable should be brought through the breakers with care, skirting coral or other rock deposits, and should be buried securely at shore end to preserve the rubber from the sun.

The tactical value of the Loop as a detection defense is directly proportional to the diligence and intelligence with which it is used. The start of a signature must not be doubted, and the fact that something is crossing the Loops must be reported to HECP or other coordinating components immediately to enable patrol vessels to be placed on alert before any attempt is made to analyze the signature in order to reek the full benefit from this

Many Loops were installed and operated at continental harbors before the war in the Pacific, and the technique which was developed during those early days has been invaluable in extending application of the Indicator Loop to Pacific harbors. Since the effective sensitivity of a Magnetic Loop decreases as the square of the water depth, its application in the many deep-water Pacific harbors was handicapped. It became apparent that some method should be devised to improve the effective sensitivity and permit deeper installations.

A Multiple-Turn Loop was installed at Espiritu Santo in an effort to attain greater effective sensitivity in deep water. This Loop was limited in its dimensions, and the amount of cable used in its construction was sufficiently small that perturbations did not become a major problem. It worked satisfactorily. Since it contained three turns, this Loop's detecting ability in 30 fathoms was approximately equivalent to that which was formerly obtained in 20 fathoms.

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An attempt was made to further improve this sensitivity at certain stations in the United States by increasing the number of turns in a Loop to 10. On short Loops where perturbations were sufficiently reduced, the system worked satisfactorily, and a sensitivity could be appreciated in 70 fathoms of water comparable with that customarily obtained in 20 fathoms. Since a practical Loop system cannot be composed of innumerable small Loops, it was not considered feasible to extend the use of this type of overseas bases. However, a device called a discriminator has been developed which will remove the effect of perturbations and will enable long ten-turn Loops to be used effectively.

These discriminators were immediately incorporated into all new harbor detection units, and use of 10-turn Loops in conjunction with the discriminator in all future detection systems is practically mandatory because of the always imminent submarine activity in war.

In addition to using Multi-Turn Loops in the outer detection line, it is highly desirable to use a second Magnetic Indicator Loop system directly to seaward of the nets. Since this area is usually relatively shallow water, these Loops, when properly operated, will detect objects approximately the size of a one-man torpedo. The principle behind this double detection plan is to initially detect larger vessels in the outer approaches of the harbor before they can discharge swimmers who are difficult to detect even on the inner Loops.

It is a recognized fact that in most Magnetic Loop systems the maximum sensitivity of which the fluxmeter is capable cannot be used because of interference caused by cable movement. For example, if a 10-foot length of cable moves ⅙ inch, the recorder pen will deflect the standard background of 4mm at 20 lines. Since the frequency of interfering signals caused by cable movement is much higher than the frequency of signals caused by the magnetic field of a ship passing over the Loop, it is possible to filter out the unwanted signals caused by cable movement, yet not interfere with those from a ship. This is the function of the discriminator unit.

The discriminator is connected electrically between the fluxmeter and the recorder unit by means of cables furnished with the unit. A minor circuit change in the recorder unit is the only one required, and the unit can be set up, adjusted and placed in operation within approximately two hours.

Use of the discriminator unit with a Multi-Turn Loop system makes it possible to attain sensitivities never before achieved under operating conditions. In one 10-turn Loop with standard spacing between legs and operating with the new discriminator unit in the circuit a maximum overall sensitivity of seven lines per mm was attained.

Average sensitivities for this system range between eight and eighty lines per mm depending upon the state of tide, etc.

All this means that such an installation should be capable of detecting an 80-foot Japanese midget submarine in 30 fathoms with ease. Also, 10-turn loops with the discriminator unit will operate at least as effectively at 70 fathoms as present single-turn Loops without the discriminator unit will at 20 fathoms.

The discriminator consists essentially of two circuits or channels, as follows:

(a) A filter circuit, which passes frequencies from 0 (DC) to .03 cycles. This circuit is made up of a filter network and a two-stage amplifier with a gain of slightly more than one. A limiter and an output stage are also included by which the output of the discriminator can be controlled so that the recorder pen will not exceed the limits of the recorder tape.

(b) A limiter circuit which operates the recentering relay of the fluxmeter recorder to recenter the galvanometer. This circuit is required because the output of the filter circuit is so delayed that the galvanometer coil would be out of control if the usual centering action operated by the pen controls were in effect. This circuit can be adjusted to operate the recentering relay of the recorder at any desired deflection of the fluxmeter galvanometer, applying a return voltage to the galvanometer coil.

A procedure has been developed to decrease the number and magnitude of cable catenaries which reduce the effective sensitivity of all Magnetic Indicator Loops. It is based upon the principle that when the cable is payed out at the proper speed, it will lay on bottom throughout its entire length and the swaying which causes perturbations will be damped out by friction between the cable and the bottom.

The ocean bottom may for practical purposes be considered as a series of "rolling hills and dales," and the cable should follow the contour exactly. If the cable leaves the ship at a constant linear velocity, the speed of the ship will need to be adjusted commensurate with the cosine of the angle of grade beneath the ship. It is also necessary that the cable vessel advance slowly enough to allow the cable to "roll" along the bottom rather than stretch between the high spots. On the other hand, the cable should not be permitted to pile up on bottom through lack of sufficient tension on the brake regardless of the advance of the cable ship. The brake should be set to at least hold the weight of cable between the ship and the bottom even when the cable vessel is dead in the water.

If this condition can be maintained regardless of the depth of the water, the cable will pay out only when the ship advances and the cable will roll along on bottom in much the same way that fence wire pays off the reel of a truck. However, when the cable vessel is dead in

the water, the cable stands vertically; but as it advances the cable no longer will increase. Consequently, there exists a somewhat complicated relationship between the proper brake tension and the advance of the ship and the depth of the water. Some of these complications can be overcome when the contour of the bottom along the course of the cable is known in advance. This information may be obtained with a recording fathometer.

It has been assumed that there were no precipitous spots in the rolling contour. Should such places be present, the cable would certainly hand in a catenary. Careful planning can frequently avoid such contingencies. The contemplated course of the Magnetic Loop cables should be run in a survey vessel equipped with a recording fathometer, taking precautions to establish the exact position of the survey vessel throughout the entire time. If the countours appear to be too steep, a second area parallel to the first should be similarly investigated. By repeating this procedure several times, it is often possible to select a location for the Magnetic Loop which is decidedly preferable. A contour projection should be drawn on the chart so that proper adjustments of brake tension and ship's speed can readily be made during the cable-laying operation. It is also advisable to have the survey vessel precede the cable vessel during the laying operation to check the contour and determine that it corresponds with that from which the cable ship plotted its contour projections.

Some idea of the effectiveness of this procedure may be had from experience in relaying some unsatisfactory Loops. The new Loops were five times better when measured for perturbation level than were the old ones. When the new Loops settled, they improved until they were eight times better than the old ones.

THE LOOP SYSTEM

(A) GENERAL DESCRIPTION

(*a*) *Purpose.*—The Magnetic Detection Loop is a fixed underwater system, designed to detect the presence of either surface or underwater vessels approaching a harbor or other vulnerable area. The system increases the effectiveness of the local patrol forces by providing a warning of attack when approaching vessels cross a "detection line," established far enough to seaward of the vulnerable area, to allow adequate searching time for location and destruction of the attacking vessel.

(*b*) *Description.*—The Magnetic Detection Loop system is basically a magnetic flux measuring circuit. A large rectangular Loop is laid at the entrance to the harbor or anchorage to be protected, and is connected to the Recording Fluxmeter equipment, located on shore. Each installation consists of three single-conductor cables laid parallel, and approximately 600 feet apart to form the Loop. The offshore ends of these cables are joined together in a "Y" splice, and the inshore ends are spliced to a three-conductor tail cable connecting the Loop with the shore terminal. The installation of the tail cable should offer little importance. The principal problem is that of maintaining uniform spacing of the three parallel cables along the specified course, especially if tidal cross currents or adverse weather conditions prevail. Since the successful operation of the terminal equipment depends upon maintaining approximately equal areas of the two Loops, which in turn depends upon uniform spacing of the three legs, considerable care must be exercised in buoying the course. It is also essential that absolutely watertight and electrically perfect splices be made to obviate any possibility of setting up "sea cells" in the Loop.

(B) FACTORS AFFECTING LOCATION

(*a*) *Depth of Water.*—The single-conductor Loop cables should not be laid in water less than 10 feet deep. In shallow water, a heavy swell may cause movement of the Loop cables. In moving, the cable will cut the earth's magnetic field and thereby cause an undesirable deflection of the Fluxmeter. For the same reason, the cable should not be laid in areas where sudden changes in depth occur. In the region of a sudden drop, the cable is not likely to be securely imbedded in the sea bottom and will tend to move with the movement of the water.

(*b*) *Nature of Sea Bottom.*—The Loop cables should be laid on a sand or mud bottom wherever possible. The cable will imbed itself in the sand or mud, and will thus retain its position. If the Loop is laid on a rocky bottom, bights may be formed and movement of the cable may result. Laying the cables over shoals should be avoided for the same reason.

(*c*) *Currents and Tidal Streams.*—Strong currents, in addition to increasing the difficulty of laying operations, may cause movement of the cable.

(*d*) *Landing Place for Tail Cables.*—When selecting the landing beach for the three-conductor tail cables, the following factors should be considered:

The tail cable is liable to be damaged if it is washed about against rocks at the landing place.

The shore should be moderately steep to allow the cable ship to approach close in, but not so precipitous as to prevent the cable from lying on the bottom.

A sheltered landing place is desirable in order to facilitate boat work.

The tail cable should come ashore at right angles to the beach and should be fairly taut, whereas the single-

conductor Loop cables should be laid as slack as possible. On rocky beaches, advantage should be taken of any natural protection such as channels or crevices between the rocks. If a rocky beach exposed to heavy seas is encountered, a concrete trench extending from high-water mark to low-water mark should be provided. If there are two or more tail cables, they should be seized together at intervals and laid in the trench.

On shore, the cable should be protected from sabotage or mischievous damage by burying it approximately 18 inches beneath the surface of the sand or soil. The distance from the landing place to the control station is not of great importance, but it should be as short as is consistent with other requirements.

A satisfactory landing will be provided if the cable can be secured below low-water mark to a jetty or sea wall, and led ashore alongside it. A sheltered beach of sand or mud also offers a suitable landing place.

(*e*) *Dimensions of Loop*—The Recording Fluxmeter equipment will operate satisfactorily when connected to a Loop whose resistance is not more than 200 ohms. This would permit using a Loop of 20 miles length, including the tail cable. However, it is not desirable to use such a long Loop, since the Fluxmeter merely indicates that a vessel has crossed the Loop, and does not indicate its location along the Loop length. Where the distance across the entrance to the protected area is considerable, it is desirable to use several Loops, none longer than three front miles, laid end-to-end along the "detection line" so that the point of crossing may be somewhat localized. The standard spacing for Loop cables is 600 feet. However, a smaller spacing may be used, if necessary, in shallow, narrow entrances. The spacing should not be less than the depth of water plus the length of the smallest vessel to be detected.

(*f*) *Proximity of Other Cables and Mine Fields.*—Both the Loop and the tail cables should be located at not less than the following distances from the nearest extraneous cables or other disturbing influences, and from mine fields:

	Yards
Communication Cables	200
A-c Power Cables	200
D-c Power Cables	3,500
D-c Railways	3,500
Mine Fields	1,000
Navigational Buoys	500
Lightships	1,000

(*g*) *Tactical Considerations.*—Tactical considerations impose the necessity of taking suitable precautions against damage to the Loops, caused by vessels engaged in the following activities.

1. Anchoring near the Loops.
2. Trawling near the Loops.
3. Towing targets, etc., across the Loop area with a long towing cable.

(C) INSTALLATION PROCEDURE

Specific methods based upon previous experience are outlined as follows and should be followed closely unless local conditions and facilities necessitate divergencies.

(*a*) *Laying Out the Course.*—The line of the center leg of the Loop should be laid out first, and properly buoyed. Two range buoys, A and B, should first be placed. These buoys should be of a size and type that will be readily visible with glasses from the distant end of the course. Buoy A should be located on the center line about 1,000 feet from the inshore end of the Loop. Buoy B should be placed at least one mile inshore of Buoy A. Suitable range markers on the beach, or some prominent objects on shore on the range are preferable to Buoys A and B, and should be substituted where conditions permit.

After Buoys A and B have been placed and properly checked, marker buoys should be placed along the center line, starting at the inshore end. Third-class nun buoys, spherical mine buoys, or small dan buoys are suitable. Type UM–15 nun buoys are furnished for most Loop installations. If satisfactory buoys are not available, metal oil drums painted white can be used. These buoys should be spaced at intervals such that at least two buoys will be visible ahead at a time under the conditions encountered. If strong cross tides prevail, the interval should not exceed one-half mile, in order to maintain proper alignment while laying.

Since the buoys may be on location for several days, it is important that they be properly anchored. Depending upon the size of the buoys and the tidal conditions, the use of 200- to 1,500-pound concrete blocks with suitable chain is recommended. If chain is not available, wire rope should be used. Manila line is not satisfactory. The length of the mooring line required for each buoy can be determined from the depth shown on the chart of the area, with no greater allowance for scope than is necessary. If cross tides prevail, all buoys should be lined up and all cables laid under the same tidal conditions, and preferably near enough to slack water so that the current is weak. Because of differences in water depth, buoys that are lined up on an ebb tide may be badly out of alignment on flood tide.

After the center line of buoys has been laid and properly checked for alignment, similar lines of buoys should be laid along the lines of the other legs. In order to maintain uniform spacing, a 600-foot length of light line should be used for checking the distance from each center buoy to the corresponding side buoy, as the distance is so short compared to the length of the Loop that any attempt to line up the side buoys by using ranges is likely to result in large errors at the outer end of the Loop.

(*b*) *Preparation for Laying.*—The cable may be laid either from a suitable ship or large barge. Certain of the

AN Net Tenders have been used for this work. A barge should not be used if the water is deep, as it is difficult to provide adequate braking for the cable. The ship or barge must be large enough to carry the cable necessary for one leg or the tail of the Loop, and it is desirable that it be equipped with some form of manual- or power-operated winch, a suitable brake applied either to the winch or directly to the cable, and fair-leads and rollers to facilitate handling the cable. Types 102 and 104 cable are sufficiently light and flexible to permit laying from any type of small lighter, buoy boat, motor boat, or barge that can carry enough cable for one leg of the Loop or for the tail of the Loop.

The weights per 1,000 feet of the different types of cable are as follows:

	Pounds
Type 101	2,000—2,100
Type 103	2,400—2,500
Type 102	470
Type 104	630
Type 111	1,390
Type 113	1,420

The cable should be spliced as it is loaded on the vessel, since it is impractical to stop while laying. If sufficient deck space is available, the cable can be figure-eighted. Where the deck space is not adequate, the cable will have to be coiled in layers either on deck or in a hold. If the cable is to be coiled, it should be done carefully, in flat, even layers, starting at the outside and coiling toward the center, then crossing over to the outside, and again coiling toward the center. This will result in laying from the inside of the coil and prevent whipping from loosening the turns. If many layers are necessary, flat strips of wood of a thickness slightly greater than that of the cable should be placed on each side of the cable at the crossover to prevent the concentrated load from flattening the cable. The inside turns should not have a diameter of less than six feet, except in the case of Types of 102 and 104 cable, which can safely be coiled as small in diameter as possible and still have a smooth coil. In both loading and laying, a large snatch block through which the cable will run should be placed over the center of the coil. This block may be suspended either from a boom or from an "A" frame erected over the center of the coil. The block should be large enough to pass the splices, and at least as high as the largest diameter of the coil. The "A" frame should be securely bolted in place and well braced, as it may be subjected to considerable strain; it should be wide enough at the bottom to span the entire coil.

On a barge, the cable is usually paid out through a block mounted over the stern. On a ship, better maneuvering ability is obtained by paying out the cable from a boom or outrigger located near the bow. One block is mounted over the coil, as described above, and another at the end of the boom or outrigger, with as many intermediate fair-leads as may be necessary. All blocks and fair-leads should be large enough to permit passage of the splices in the cable. If the cable is laid in deep water, some form of braking device is necessary. On a ship equipped for cable work, there will usually be a 6-foot drum equipped with brakes and power drive, which can be utilized to pay out or take in cable, as necessary. No cable of this type should be hauled over a drum less than four feet in diameter. An improvised braking device which is usually effective in moderate depths of water consists of a snatch block mounted between two fixed fair-leads a few apart, in such a manner that it can be hauled out of line with blocks and tackle. This hauls a bight in the cable which acts as a drag. Under proper conditions, a friction brake may be applied directly to the cable just before it goes over the side.

(NOTE—The actual laying of the Loop is described in a separate article.)

(D) CABLE-SPLICING PROCEDURE

The necessary instructions for making vulcanized splices in Types 101, 103, 111, and 113 cable, and for making "cold" splices in Types 102 and 104 cable are given below. The types of splices are as follows:

Vulcanized or Cold Splices—

1. Straight splice, Types 101 and 111 cable.
2. Straight splice, Types 103 and 113 cable.
3. Tail splice, used for joining three single-conductor cables to one three-conductor cable.

4′. **Y** splice, used for joining together three single-conductor cables in a **Y** formation.

"Cold Splices"—

1′. Straight splice, Type 102 cable.

2′. Straight splice, Type 104 cable.

3′ Tail splice, used for joining three single-conductor cables to one three-conductor cable.

4′. Y splice, used for joining together three single-conductor cables in a **Y** formation.

(*a*) *Materials and Equipment.* — A splicing kit for Types 101, 103, 111, and 113 cable contains the following items:

40 sleeves, tinned copper, split, No. 6 stranded (Type 101 kit only).
5 sleeves, tinned copper, split, No. 2 stranded (Type 101 kit only).
40 sleeves, tinned copper, split, No. 9 stranded (Type 111 kit only).
5 sleeves, tinned copper, split, No. 4 stranded (Type 111 kit only).
12 sheets sandpaper, medium.
1 pound rosin-core solder (50 percent tin).
1½ quarts rubber cement.
20 rolls Type AA-60 Anhydrex splicing tape.
12 rolls friction tape, in ¾-inch rolls.
500 feet wire, galvanized iron, No. 12 BWG (0.109-inch).
3 quarts benzol or carbon tetrachloride.

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A splicing kit for Types 102 and 104 cable contains the following items:

75 sleeves, tinned copper, split, No. 9 stranded.
5 sleeves, tinned copper, split, No. 4 stranded (for Y splices only).
20 rolls Type AA-60 Anhydrex splicing tape.
1 pound rosin-core solder (50 percent tin).
2 quarts rubber cement.
18 rolls friction tape, ¾-inch.
43 rolls Type 60 Jacket Splicing Compound.
750 feet wire, galvanized iron, No. 16 BWG.
5 quarts weatherproof paint.
100 feet wire, tinned copper, No. 22 (for binding steel supports).
12 sheets sandpaper, medium.
3 quarts carbon tetrachloride.

The following tools will be required for splicing these cables (those marked with an asterisk are necessary only when making vulcanized splices):

1 pair pliers, side-cutting, 8-inch.
1 pair pliers, long-nose, 6-inch.
1 pair pliers, oblique-cutting, 5-inch.
1 file, flat, 6-inch.
1 rule, folding, 48-inch.
1 screw driver, 6-inch.
2 soldering coppers, 1½ pound per pair for Types 102 and 104 cable, 3½ to 4 pounds per pair for Types 101, 103, 111, and 113.
1 hacksaw frame.
12 hacksaw blades, medium.
1 knife (similar to paring knife).
1 oilstone, Carborundum, combination.
1 blowtorch.
1 hammer, carpenter's, bell-faced.
1 serving stick.
*1 vulcanizer, electric, CG Type D–93.
*1 vulcanizer mould, straight splice, CG Type C–100 for Type 101 cable, or Type C–111 for Type 111 cable.
*1 vulcanizer mould, Y splice, CG Type C–100—Y for Type cable, or Type C–111–Y for Type 113 cable.
*1 storage battery, 6-volt (any automotive battery is suitable).
*1 thermometer, immersion, Weston dial-type, O–400° F., in case.
*1 tooth brush.
*1 outside calipers, small.

Suitable splicing racks can be constructed of 2- by 3-inch or 2- by 4-inch lumber. If only a few splices are contemplated, the clamps may be omitted and the cable lashed to the crosspiece. A cleat on the inside of each pair of legs supports a removable shelf, on which the vulcanizer is supported during vulcanizing operations. The shelf is then removed to provide clearance for replacing and serving the armor.

There are numerous types of serving sticks or serving mallets, most of which can be used for serving the armor wire. One of the simplest forms, suitable for making a few splices, is an oak or ash stick about 1½ by 2 inches and about 30 inches in length, with the ends tapered and rounded to permit a comfortable grip, and a small hole drilled through the center just large enough to take the serving wire. When the hole wears, a new hole can be drilled. Whatever the form of serving stick used, its design should be such that it does not scrape the galvanizing from the serving wire. Therefore, metal sticks or inserts are not advisable.

Soap solution should be made up in advance by dissolving soap flakes or mild, white soap in water to form a solution of a light, creamy consistency. Avoid soap with a high alkali content.

(*b*) *Preparation of Ends.*—Types 101 and 111 Cable. Regardless of the type of splice to be made, the ends of these cables are prepared for splicing in the following manner:

(1) Saw off the factory end, or any damaged cable. Place two layers of friction tape over the jute, starting 24 inches from the end of the cable and taping away from the end for a distance of 2 inches, and then back to the starting point. Place a temporary serving of two turns of No. 12 galvanized-iron wire over the tape, 24 inches from the end of the cable. This temporary serving holds the jute and armor in place when the ends of the armor wires are laid back. It is also the reference point from which the other dimensions noted below are measured.

(2) Lay back the two layers of jute, and cut them off close to the temporary serving. Lay back the armor wires one at a time, straighten, and bend back over the serving. The ends laid back should be 24 inches long.

(3) Cut off the core of the cable with a hacksaw about 10 inches from the serving. Carefully remove the tape over the jacket to a point about 1 inch from the serving. Remove the rubber jacket to a point 3 inches from the serving, taking great care not to injure the rubber insulation over the conductor. Remove the conductor tape to a point about ½ inch from the end of the jacket. Remove the rubber insulation to a point 6½ inches from the serving.

(4) Carefully taper the end of the jacket with a sharp knife, making a smooth cone about 1 inch long. Clean the jacket back of the cone, and smooth the cone with sandpaper. Taper the end of the insulation, making a cone about ¾ inch long, and clean the insulation with sandpaper. It is essential that all cones be well made and smoothly tapered.

(5) If a straight splice or tail splice is contemplated, cut off the conductor ¾ inch from the coned rubber, and tin it with rosin-core solder to form one solid conductor. Do not use soldering paste or acid flux of any kind, as any remaining acid may set up minute potentials. Wipe off any remaining solder that might interfere with inserting the conductor in the sleeve.

(6) If a Y splice is contemplated, cut off the conductor 2 inches from the coned rubber. Open up the strands and cut out two on opposite sides. Clean, straighten, and tin the remaining strands individually. Wipe off all surplus solder. Although the strands were tinned originally, the retinning is essential to a securely soldered joint as there is frequently a light film of grease remaining after the

original stranding process.

Types 103 and 113 Cable. The ends of these cables are prepared for splicing as follows:

(1) Saw off the factory end, or any damaged cable. Apply two layers of tape and a temporary wire serving, remove and cut off the two outer layers of jute, and lay back the armor wire as outlined for Types 101 and 111 cable.

(2) Lay back the two inner layers of jute to a point about 1 inch from the serving, but do not cut them off. With the hacksaw, cut off the core of the cable about 10 inches from the serving. Remove the tape over the core, and cut it off about 3 inches from the serving. Lay back, but do not cut off, the jute fillers between the conductors. Remove the tapes from the individual conductors to a point about 4 inches from the serving. Remove the rubber insulation to a point 6½ inches from the serving.

(3) Carefully taper the end of the insulation on each conductor, making a smooth cone about ¾ inch long, and clean the insulation back of the cone with sandpaper.

(4) Cut off the conductor ¾ inch from the coned rubber, and tin it with rosin-core solder to form one solid conductor. Wipe off any remaining solder that might interfere with inserting the conductor in the sleeve.

Type 102 Cable. The ends of this cable are prepared for splicing in the following manner:

(1) Saw off the factory end, or any damaged cable. Remove the outer rubber jacket, exposing the armor to a point 15 inches from the end of the cable. Place a temporary serving of two layers of friction tape around the jacket at this point to hold the jacket and armor in place when the ends of the armor are laid back. Lay back the armor wires one at a time, straighten, and bend back over the serving. The ends laid back should be 15 inches long.

(2) Cut off the core of the cable with sidecutting pliers about 6½ inches from the serving. Carefully remove the tape over the rubber insulation to a point about 1½ inches from the serving. Remove the rubber insulation from the conductor to a point 4¼ inches from the serving.

(3) Carefully taper the end of the insulation, making a cone about ¾ inch long, and clean the insulation with sandpaper. It is essential that the cone be well made and smoothly tapered.

(4) If a straight splice or tail splice is contemplated, cut off the conductor ¾ inch from the coned rubber, and tin it with rosin-core solder to form one solid conductor. Do not use soldering paste or acid flux of any kind, as any remaining acid may set up minute potentials. Wipe off any remaining solder that might interfere with inserting the conductor in the sleeve.

(5) If a Y splice is contemplated, cut off the conductor 2 inches from the coned rubber. Open up the strands, and cut out two on opposite sides. Clean, straighten, and tin the remaining strands individually. Wipe off all surplus solder. Although the strands were tinned originally, the retinning is essential to a securely soldered joint as there is frequently a light film of grease remaining after the original stranding process.

Type 104 Cable. The ends of this cable are prepared for splicing as follows:

(1) Saw off the factory end, or any damaged cable. Remove the outer rubber jacket and the seine twine to a point 15 inches from the end of the cable. Place a temporary serving of two layers of friction tape at this point to hold the jacket intact. Remove the rubber from the steel reinforcing strands to a point 2 inches from the serving.

(2) Cut off each of the three conductors with side-cutting pliers 6½ inches from the serving. Carefully remove the tape over the rubber insulation to a point about 1½ inches from the serving. Remove the rubber insulation from the conductor to a point 4¼ inches from the serving.

(3) Carefully taper the end of the insulation on each conductor, making a smooth cone about ¾ inch long, and clean the insulation back of the cone with sandpaper.

(4) Cut off the conductor ¾ inch from the coned rubber and tin it with rosin-core solder to form one solid conductor. Wipe off any remaining solder that might interfere with inserting the conductor in the sleeve.

(*c*) *Single-Conductor Straight Splice.* — To make a single-conductor straight splice, clamp the two ends to be spliced together in the splicing rack, and prepare them for splicing. Then adjust the two ends in the rack so that there is a small amount of slack when the ends of the conductor are brought together.

Insert the two tinned copper conductors into a No. 6 sleeve for Type 101 cable, or into a No. 9 sleeve for Types 102 or 111 cable. Make sure that the ends butt together in the center of the sleeve. The slot in the sleeve should be at the top. Squeeze the sleeve slightly with pliers to clamp the wires firmly. Heat the sleeve by placing a hot soldering copper under it, using a little solder on the copper to insure good thermal contact. As soon as the sleeve is hot, run rosin-core solder into the slot until it is filled and excess solder runs out the ends. Acid flux or soldering paste of any kind must be avoided in splicing conductors, or minute galvanic cells may be set up that will interfere with satisfactory operation. Sufficient heat must be applied to insure a well-soldered joint, and to float out the surplus rosin. A direct flame should never be applied to the sleeve, as it will damage the adjacent insulation. If necessary, a flame may be applied to the base of the soldering copper while its tip is held against the sleeve. Wipe off any surplus solder with a dry cloth and then cool the joint with a cloth wet in fresh water. If any rough points of solder project that might puncture the insulation, dress them down with a small file. Test the joint by

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grasping both conductors, and exerting as much tension as possible.

After the joint is soldered, wash the sleeve and adjoining insulation with carbon tetrachloride to remove any moisture. Cloth used for the purpose should be lintless. Rubber cement should then be applied to the sleeve, cones, and the insulation behind the cones, and well rubbed in with clean fingertips. Use benzol or carbon tetrachloride to remove tar, rubber cement, or grease from the fingers—or tar from the insulation—as foreign substances on the insulation or splicing compound will result in faulty adhesion.

When the cement has dried, apply the special Anhydrex rubber tape. It should be applied in smooth even layers, starting near the center, taping part way up one cone, then back, and part way up the opposite cone. Continue taping in even layers, carrying each layer farther up the cone. As the tape is wrapped on, care must be taken to apply even tension all around, and not concentrate the pull in one direction. The tension should be sufficient to reduce the tape to half its original width. The tape should be applied with a 50 percent overlap. Do not attempt to use too long pieces of tape, but avoid joints near the cones. Stretch the end well before starting to apply a length of tape, and stretch and break it off just before reaching the opposite end, so as to avoid bunches. Be sure all particles of cotton backing are removed from the tape. If the tape inadvertently becomes creased or stuck together, discard it and take a fresh length, as bunches and air pockets must be avoided. For Types 101 or 111 cable, where the patch is vulcanized, carry the final layers of tape back of the cone to make a patch exactly 4⅛ inches long, and slightly over $\frac{9}{16}$ inch in diameter. The diameter can be determined with a pair of outside calipers set to the diameter of the mould. The minimum diameter at any point should be slightly greater than the diameter of the mould, so that the calipers bind slightly when slipped over the patch. High spots should be avoided as much as possible. If too much rubber is applied, the patch will not seat properly in the mould, and may result in the sleeve being out of center after vulcanization. Too little rubber will result in pockets in the finished patch. If the correct amount is used, a small surplus will squeeze out as the mould is set up and form a small fin. For Type 102 cable, carry the final layers of tape back of the cone to make a patch approximately 4½ inches long, and not less than $\frac{7}{16}$ in diameter. Then apply three layers of friction tape with a 50 percent overlap the entire length of the conductor, overlapping the original conductor tape.

Before the joint in Types 101 or 111 cable is taped, the C–100 or C–111 mould should be placed in the vulcanizer, the battery connected to the vulcanizer, and the moulds allowed to warm up. When taping is completed, place the shelf in the splicing rack and set the vulcanizer in the center of the shelf, slacking off the cable a little if necessary. Open the moulds, and apply the soap solution to the inner surfaces with a tooth brush. Insert the taped patch in the mould, making sure that is properly centered and seated, and close the mould until some pressure is exerted. Then continue closing slowly, allowing the rubber time to warm up and the surplus to flow out. When the moulds are seated, close the cover, making sure that the projecting cable lines up with the mould, as any pressure exerted by a bent conductor may tend to force the sleeve off center while the rubber is in a soft plastic condition. Vulcanize for 10 minutes at 300° F. In cool or windy weather, it is advisable to throw some protecting cover over the vulcanizer to keep the wind from blowing through the end slots. When the time is up, remove the splice, and cool immediately by applying fresh water with a cloth. When cool, trim off the fins. Apply the thumbnail with pressure to various points around the patch. Any irregularity in centering or thin spot is easily detected in this manner by the reduced resiliency. If the splice is badly out of center, it will be necessary to make a new patch.

When a satisfactory vulcanized patch has been obtained, and the conductor tape has been patched, clean off the patch, adjacent insulation, and jacket cones with carbon tetrachloride, and apply a coating of rubber cement, which should be well rubbed in. When the cement is dry, apply Anhydrex rubber tape over the insulation and patch, carrying each successive layer farther up the jacket cone, until the core has been uniformly taped to the diameter of the original jacket. Then apply two layers of friction tape the entire length of the core and overlapping the original core tape.

The splice for either type of cable is now ready to armor. Remove the vulcanizer shelf (if it was used) from the rack, and adjust the cable in the clamps so that it is straight and free of all slack. Bend back the armor wires until they radiate from the cable at an angle of 90° to its axis, making sure that the wires are straight and equally spaced around the cable. Remove the temporary wire servings at the ends of the splice (on Types 101 or 111 cable). Then lay each armor wire parallel with the cable, laying them down alternately from the right and left so that they cross in the center of the splice. When all the wires have been replaced, lash them down temporarily at each end, and hammer or squeeze them into position around the cable, adding new lashings as necessary. When this operation is finished, the splice should be uniformly surrounded with armor wires.

Make up a small hand coil of No. 12 galvanized-iron serving wire for Types 101 or 111 cable (for Type 102 cable use No. 16 galvanized-iron wire). Insert one end through the hole in the serving stick so that it projects about 15 inches. Pry up one of the armor wires with a screw driver, about ½ inch to the left of the center of

the splice. Slip the serving wire under the armor wire, and make one turn around the armor wire to hold it in place. Bend the end of the serving wire down parallel with the cable and pointing to the right. Hammer the armor and serving wire into place and start serving to the right. As one man turns the serving stick, an assistant should pass the coil of serving wire around the cable, keeping about one turn behind, in order to keep adequate tension on the serving wire. Apply 10 turns of serving wire, and secure it by pigtailing it to the original end.

Remove all temporary lashings and turn back six armor wires over the center serving in each direction, and hammer them down into place. The pairs of armor wires turned back should be uniformly spaced around the cable. Then, starting as close to the center serving as possible, serve down both sides of the splice with the serving wire. On Types 101 or 111 cable, carry each serving about 1 inch beyond the point from which the temporary serving was removed. On Type 102 cable, stop the serving about ½ inch before reaching the end of the jacket. Turn all armor wires back over the servings, cut them off about ¼ inch from the bend, and hammer them down.

On Type 102 cable, remove the temporary friction tape servings, and cone the jacket for approximately 1½ inches. Clean the surface with carbon tetrachloride, and apply rubber cement to the cones and to the armor. Tape with Type 60 Jacket Splicing Compound, building up to a diameter of 1¼ inches, and overlapping the cable jacket for a distance of 1½ inches. Wrap the entire splice with three layers of friction tape, allowing 25 percent overlap. Then apply a coat of weatherproof paint over the entire splice.

(*d*) *Three-Conductor Straight Splice.*—Place the two ends of three-conductor cable in the rack and prepare the ends. Splice one of the single-conductor cables to each of the three conductors of the three-conductor cable. The three conductors have red, white, and blue tapes, respectively, over the insulation, and the conductors should ordinarily be spliced color-to-color. However, in certain instances where a length of cable has been rereeled or turned end-for-end, splicing color-to-color would necessitate a cross-over in the splice. In that case the white conductors should be spliced together, and the red and blue conductors transposed to preserve the original formation. The detailed connections should be recorded.

After splicing the conductors of Types 103 or 113 cable, apply rubber tape, and vulcanize. When satisfactory patches have been obtained, apply a layer of friction tape over each patch, carrying it back over the original conductor tapes. Replace the jute fillers between the conductors, and apply a layer of friction tape over the core. This tape should overlap the originl core tapes. Replace the two inner layers of jute as evenly as possible, and secure with wrappings of friction tape. The splice should then be armored and served in exactly the same manner as single-conductor cable.

After splicing the conductors of Types 104 cable, apply rubber tape and friction tape over each splice. Lay the three insulated conductors close together, omitting the reinforcing strands and inserting lengths of marlin in their place. Apply four layers of friction tape over this core. Fan out the strands of the three steel reinforcing conductors, and lay each strand parallel with the cable, laying them down alternately from the right and left so that they cross in the center of the splice and uniformly surround the cable. Apply temporary lashings at each end of the splice. Then apply a center serving, consisting of 10 turns of No. 22 tinned copper wire. Remove the temporary end lashing, and turn back all the strands over the center serving in each direction. Then, starting as close to the center as possible, serve the splice in each direction, stopping each serving at a point about ½ inch before reaching the end of the jacket.

Remove the temporary tape servings, cone the jacket, and apply a rubber jacket patch and friction tape. Then apply a coat of weatherproof paint to the entire splice.

(*e*) *Tail Splice.*—Place the three ends of single-conductor cable in the clamp at one end of the splicing rack, and the three-conductor cable in the clamp at the opposite end. Splice one of the single-conductor cables to each of the three conductors of the three-conductor cable. For the sake of uniformity, the center, or common, leg should be spliced to the white conductor, the offshore leg to the red conductor, and the inshore leg to the blue conductor.

Types 101, 103, 111, and 113 Cable Only. After satisfactory patches have been obtained, apply rubber cement to the jacket cones, insulation, and patches, and apply Anhydrex rubber tape in even layers. As there is no jacket over the insulation on the three-conductor cable, the rubber applied should taper off gradually on the three-conductor side, but should be built up to the diameter of the original core on the single-conductor side. Apply a layer of friction tape over the rubber.

Loosen the clamp over the single-conductor cables and bind the three cables together with temporary lashings into a triangular formation. Before lashing the cables together, the armor wire that has been laid back should be bent out to an angle of 90 degrees to the axis of the cable, and worked around to the outside of the triangular formation to form a single circular radiating group. Then the clamp should be tightened.

Fill the interstices between the conductors with jute or marlin to form a smooth, round tapered core. Apply one layer of friction tape next, in the case of a splice between Types 101 and 103 cable, or between Types 111 and 113 cable, then restore the two inner layers of jute on the three-conductor end, gradually tapering it off

toward the larger end, and secure it with friction tape. In the case of a splice between Types 102 and 104 cable, the reinforcing strands of the three-conductor cable should be omitted in filling the interstices, and four layers of friction tape applied.

Types 101, 103, 111, and 113 Cable: Restore the armor, and serve the cable. As the end consisting of three cables will contain more armor wires than the end consisting of one cable, it will be necessary to replace two or three wires from one end, to one from the other. Carrying the servings back at least 2 inches over the three separate single-conductor cables. Place a separate serving of No. 12 galvanized-iron wire about 3 inches long over the three single-conductor cables at a point about 15 inches from the end of the splice, to bind them securely together. At a point about 6 feet from this serving, apply two layers of canvas about 3 inches wide to each single-conductor cable for a distance of about 30 inches, and secure in place with marlin. Connect the three cables together with $\frac{3}{16}$ inch or $\frac{1}{4}$ inch chain, half-hitched to the cable over the canvas protective wrappings. The additional wire serving and the chain lashing are intended to prevent imposing any lateral strain on the throat of the splice.

Types 102 and 104 Cable: Fan out the reinforcing strands, and use them as a substitute for the armor. When the armor is laid in place, the end, consisting of three cables, will contain more armor wire than the end containing the reinforcing strands. Therefore, it will be necessary to replace two or three wires from one end, to one from the other. The armor should cross in the center of the splice and uniformly surround the cable. Apply temporary lashings at each end of the splice. A center serving of 10 turns of No. 16 galvanized-iron wire should be applied. Then remove the temporary end lashing and turn back all the reinforcing strands and about 12 of the armor wires over the center serving. The armor wires that are turned back should be selected uniformly around the splice. Start as close to the center serving as possible and serve the splice in each direction, stopping each serving at a point about $\frac{1}{2}$ inch before reaching the end of the jacket. The armor wires should be locked by bending them back over the serving, cutting them all of about $\frac{1}{4}$ inch from the bend, and hammering them down.

Types 102 and 104 Cable: Remove the temporary tape servings, cone the jacket and apply a rubber jacket patch, taking care that the spaces between cables on the three-cable end are well filled, and paint the entire splice with weatherproof paint. At a point about 15 inches from the end and again at six feet from the end of the splice, apply canvas wrapping over the three cables, and place a separate serving of No. 16 galvanized-iron wire about 3 inches long to bind them tightly together.

(*f*) Y *Splice.*—Insert the end of the center leg of the loop in one end of the splicing rack and the two outer legs in the opposite end. For Types 101 or 111 cable, prepare the three ends. Insert the strands of the three conductors into a sleeve (No. 2 for Type 101, No. 4 for Types 102 and 111), so that the ends overlap and run the entire length of the sleeve. The tips of the foreshortened strands should be soldered to the strands which enter the sleeve.

After the joint has been soldered, clean the splice and apply rubber cement. Then apply Anhydrex rubber tape as follows:

(1) Types 101 and 111 Cable. Apply the rubber tape to form a patch conforming to the size and shape of the Y mould. First tape the two arms of the Y separately to the required diameter from the coned insulation to the point where the two conductors enter the sleeve, spreading the two arms apart as much as possible to facilitate taping. Then bend the two arms so that they conform to the angle of the mould. Cut short lengths of tape, and roll them tightly to form small wads. Force these wads into the throats of the Y, pressing them firmly into place to fill all voids at the junction point, and tape them in place. Finally, the base or tail of the Y should be taped in the same manner as a single-conductor splice. The diameter of the tape over the sleeve and at the ends should be $\frac{21}{32}$ inch and the total length of the splice $4\frac{3}{4}$ inches. If carefully made, the patch will be the same shape as the Y mould and will exceed its dimensions slightly. If the outlines of the mould are marked on a piece of cardboard which is held under the patch, it will be of material assistance in taping the patch to the desired shape and dimensions. By chalking the edges of the mould and clamping the cardboard between the halves of the mould, the outline is readily transferred to the cardboard. Calipers should also be used to check the cylindrical portions of the patch.

(2) Type 102 Cable: Tape first over one arm and down the base of the Y, and then over the other arm and down the base, alternately with each layer, starting near the points of the cones and gradually working up the cones as additional layers of tape are applied. For the first few layers, bend the two arms apart as much as possible, in order to get the tape well down between the two conductors. After the first few layers, bring the arms closer together so that they form an angle of about 30°. Continue taping until the insulation is built up to about one and one-half times its original thickness, and the throat of the Y is tightly sealed.

Types 101 and 111 Cable Only: Before vulcanizing the patch make sure that the patch is properly made, and that the angle between the two insulated conductors is exactly the same as that of the mould. This is very important, as otherwise the patch will not seat properly in the mould and any strain on the conductors will force the sleeve to one side of the patch while the rubber is

warm and plastic. If the two cables forming the arms of the Y are clamped in the rack on 10-inch centers as measured at the inside edge of the rack and if the end of the patch is 31 inches from the inside edge of the rack, the angle will be approximately correct. To avoid twisting the splice, place the vulcanizer on end on the shelf with the clamping crank uppermost. Apply soap solution to the mould, insert the patch, and vulcanize 12 minutes at 300° F.

Types 101 and 111 Cable Only: When a satisfactory patch has been obtained, cooled, and trimmed, and the conductor tape has been patched, apply rubber cement to the jacket cones, insulation, and patch and tape, except that but one layer of friction tape is necessary.

Loosen the clamp on the rack and bring the two cables forming the arms close together, and apply temporary lashings. Before lashing the cables together, however, the armor wire that has been laid back should be bent out to angle of 90° to the axis of the cable, and worked around the formation to form a single radiating group.

Fill the interstices between the two cores with jute or rope yarn. Then apply two layers of friction tape on Types 101 or 111 cable to form a smooth, round, tapered core. On Type 102 cable, three layers of friction tape should be used.

Restore the armor wire over the splice, laying down two strands from the double end and then one strand from the single end alternately until all the armor has been replaced. On Types 101 and 111 cable, carrying the serving back at least 2 inches over the separate cables. Place a separate serving of No. 12 galvanized-iron wire about 3 inches long over the two cables at a point about 15 inches from the end of the splice to bind them tightly together. At a point about 6 feet from this serving, apply canvas wrappings to each cable and connect them together with $\frac{3}{16}$ inch or $\frac{1}{4}$ inch chain.

Type 102 Cable Only: Remove the temporary friction-tape servings, and cone the jacket for approximately $1\frac{1}{2}$ inches. Clean the surface with carbon tetrachloride, and apply rubber cement to the cone and armor. When the cement is dry, apply the Type 60 Jacket Splicing Compound in smooth even layers, starting near the center, taping part way up one cone, then back and part way up the opposite cones on the Y. Carefully tape the throat of the Y so that there is no possibility of water entering the splice at this point. As the tape is wrapped on, care must be taken to apply even tension all around, and not concentrate the pull in one direction. The tension should be sufficient to reduce the tape to half its original width, and it should be applied with a 50 percent overlap. Do not attempt to use too long pieces of tape, but avoid joints near the cones. Be sure that all particles of cotton backing are removed from the tape. If the tape inadvertently becomes creased or stuck together, discard it and take a fresh length, as bunches and air pockets must be avoided. Carry the layers back about $1\frac{1}{2}$ inches beyond the cone, and build up to $1\frac{1}{4}$ inches in diameter. Apply three layers of friction tape with a 50 percent overlap to cover the entire length of the splice, and then a coat of weatherproof paint. At a point about 15 inches from the end, and again at 6 feet from the end of the splice, apply canvas wrapping over the two cables and place a separate serving of No. 16 galvanized-iron wire about 3 inches long to bind them tightly together.

(*g*) *Practice Splices.*—As the making of good splices requires some skill, particularly in obtaining satisfactory vulcanized patches, it is suggested that a number of sample splices be made before proceeding to the job. Short sections of insulated conductor should be spliced first (and vulcanized, if required, using both types of mould) until satisfactory results are obtained. By cutting away sections of such practice work, poor centering and other defects can be observed, and a proper technique developed.

After satisfactory results have been obtained with short pieces of insulated conductor, the practice should be continued with pieces of the entire cable, in order to become familiar with the other processes and the added difficulties encountered in vulcanizing when movement is restricted by the adjourning armor. At least one complete, satisfactory splice of each type should be made before proceeding to the job.

FLUXMETER OPERATION

In starting the first watch after installation is completed or in switching to a stand-by unit, it is necessary to observe carefully a very definite routine of manipulating controls, and recording such data as is required to start the detection job quickly. These steps must be memorized in their exact order. Each must be studied until its purpose is fully understood so that the operator can be certain of doing the right thing quickly at the right time to set up properly all controls to operate without risk of damaging the equipment. The Fluxmeter device will give faithful performance and long, uninterrupted use but will stand very little abuse. It is important to learn thoroughly how to handle it and then to operate it with complete confidence.

The 12 steps that must be taken to start the first watch are as follows: (Assuming that the unit is prop-

[redacted]

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erly connected and balanced and that the power switch is on.)

1. Sign on.
2. Set Centering Control to "OFF" position.
3. Turn Sensitivity control to "O".
4. Center galvanometer with Return Voltage control.
5. Hold pen and turn Recorder switch to "ON".
6. Turn Centering Control to "Manual" position. If necessary, press Slow Chart button after pen reaches zero.
7. Open Shunt switch.
8. Turn Centering Control to "Automatic" position.
9. Place Sensitivity control to proper setting.
10. Make calibration.
11. Enter chart data.
12. Enter log data.

These steps should be read again and with each one referred to the Recorder case shown in Diagram No. 1. The operator will observe that all of the controls listed are on the left-hand side of the Recorder. This simplifies the job of learning their location and emphasizes the fact that in normal operating the setting of any controls on the right-hand side will not be altered until instructions have been received in their manipulation. It will be necessary however, to take certain readings from that side.

Each step will now be taken to learn of its purpose and application.

No. 1. Sign on.

Diagram No. 2 shows a sample of the Recorder chart paper on which signatures are recorded.

The chart paper is inscribed with all necessary data to furnish full details of all happenings concerning it for the watch periods it covers, and each completed

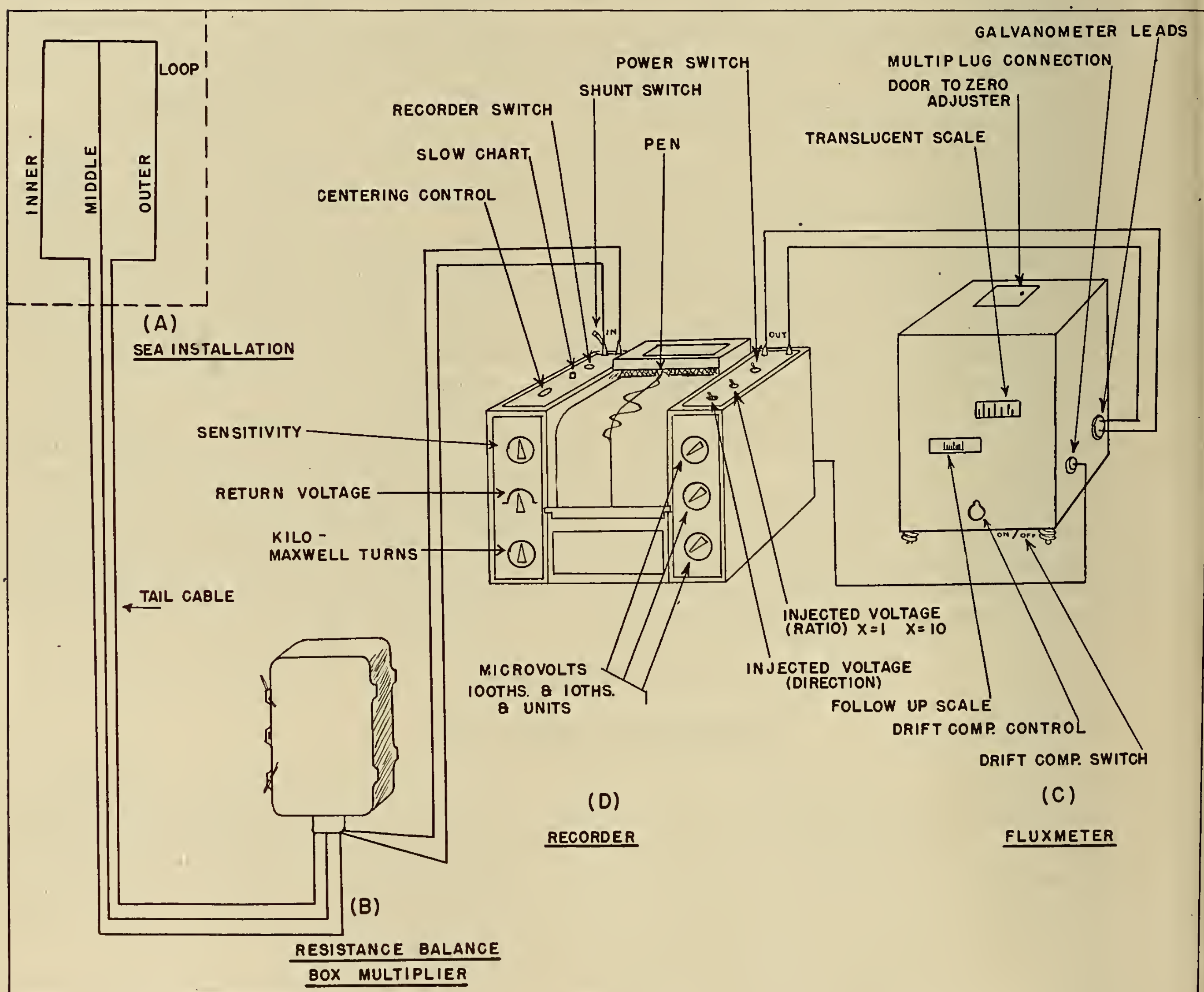


Diagram 1.

roll is placed in a permanent file. Among other details, the chart shows the name of each operator on watch and accounts for each moment of his watch period. Hence in starting a watch on the Fluxmeter, the first thing the operator does is to draw a line across the paper exactly at the point of the pen and "sign on" above the line with the hour and date the watch starts.

It will be noted that Greenwich Meridian Civil Time (G.M.C.T.) is used. All verbal and written reports are made in "Greenwich" time to avoid the possibility of any time error between different time zones.

The ruled portion of the chart paper is 100 millimeters (mm.) wide (slightly less than four inches). Since the Recorder pen deflects back and forth describing an arc on both sides of its inactivated midpoint or "zero" point, the lengthwise ruled lines are numbered from "0" (zero) at the center of the chart to 50 mm. in each direction. There are five principal division rulings at 10, 20, 30, 40, and 50 mm. points on both sides of zero. Each 10 mm. division is ruled into five spaces of 2 mms. each. Thus the operator can take a direct reading of the number of millemeters the pen deflects away from zero when a ship crosses over the Loop and so determine the relative sizes of ships.

Cross-wise curved rulings are ½ inch apart and correspond to the curve or arc described by the pen in a full scale deflection on both sides of zeo. The chart paper travels outward at the rate of 1 inch per hour (½" div. each ½ hour) when the Recorder is "idling" and not recording a ship's signature. When a ship starts over the Loop the pen begins to move away from the zero point, touches an electric contact and a high speed motor instantly takes over to accelerate the chart speed to 1 inch per minute (½" div. each ½ minute). Knowing the speed of the chart paper we can calculate the speed at which a ship is travelling by reading the elapsed time between points in the signature corresponding to the progress of the ship over the respective legs of the Loop.

One should know briefly the action occurring when the pen touches the contact points actuating the high speed motor. These contact points are attached to a hinged metal bar extending across the width of the chart track back of the pen point. There are two contacts, one on each side of the pen about 10 to 12 mms. distance from it and extending above the pen shaft level. When contacted by the pen they close a relay circuit which starts the high speed motor and also pulls the bar and contacts below the level of the pen shaft. This permits the pen to deflect across the full 50 mm. width of the chart paper from each side of zero without any interference while a signature is being recorded. When the high speed motor starts, a buzzer alarm sounds to indicate to the operator that the machine needs his immediate attention.

The matter of signing on the chart requires but a moment and the operator is now ready to set the equipment into operation.

No. 2 Place Centering Control to "OFF".

In this position the operator takes one of the precautionary steps against damaging the equipment when the Recorder switch is turned on.

No. 3 Turn Sensitivity control to "O".

Likewise, this step prevents damage when turning on the Recorder switch.

No. 4 Center galvanometer with Return Voltage control.

It is of utmost importance that the galvanometer coil be exactly in its zero position (in perfect central alignment with the axis of the two pole pieces between which it is suspended) before setting the unit in operation. Otherwise there would occur a violent disturbance when the Recorder switch is turned on, at which time the Recorder pen must almost instantly assume the same position relative to its zero point as is the galvanometer coil to its zero position. Since the deflection distance of the pen is magnified many times over that of the galvanometer coil, it can be readily seen how serious damage could result if the coil was even slightly away from its zero and the fragile tubing pen unit were required to jump violently from a resting point at zero to perhaps its extreme outer limit of deflection.

The position of the galvanometer coil is checked by noting the position of the round beam of light on the translucent scale in the front of the Fluxmeter case. (See unit "C" in diagram No. 1.) A light beam is directed against a mirror attached to the top of the coil and is reflected to the translucent scale. By turning the Return Voltage control to left or right the galvanometer is deflected in the direction desired to bring the light beam to the exact zero point in the center of the scale.

Do not be alarmed by the fact that turning the Return Voltage control in one direction may cause the light to move in different directions at different times. This circuit is in the Injected Voltage circuit (see right hand side of Recorder Case), the direction of which can be changed for control purposes from one side to the other by reversing the polarity switch marked with arrows. If the first turn of the control moves the light beam in the wrong direction, merely turn the control to the opposite side.

The three necessary preliminary steps requiring manipulation of controls preparatory to turning on the Recorder have now been completed. Quickly, before the galvanometer can slide away from zero, the operator will now:

No. 5 Hold pen and turn Recorder switch to "ON".

While the term "hold" pen is used, it actually is meant that two fingers of the right hand should be rested on the writing table of the Recorder, one on each side of the pen and each about ⅛ inch from the pen, so that a deflection of the pen will result in its bumping against the finger instead of a contact point. Failure to do this has resulted in the pen striking a contact so violently as to bend the pen to nearly an L shape. It is not at all out of the ordinary for the pen to make this first sudden jump but the shock can be cushioned against the finger, and while the pen shaft may be pressed into a slight arc until it "settles down" to its resting position, no harm will result if a good zero setting of the galvanometer has been obtained.

The shock is not great enough to be felt appreciably by the finger, and there will be no electrical shock if the operator does not reach too far into the unit. Care must be exercised to not touch any contact points, including the silver sleeve on the pen shaft.

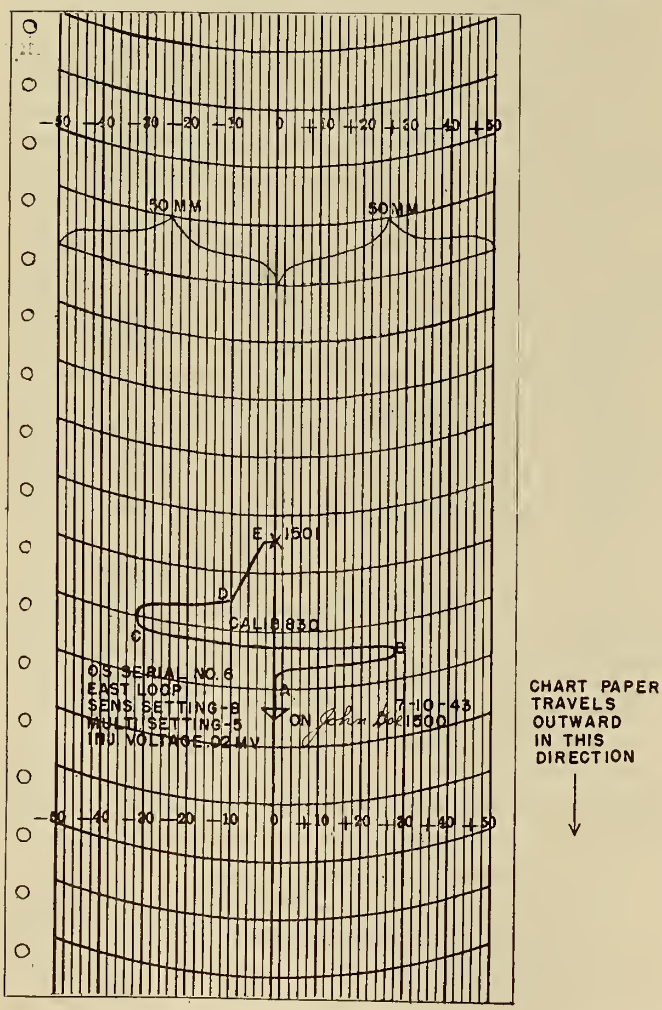


Diagram 2.

These points will pick up salt always present on the surface of the operator's skin, which will cause corrosion and an unsatisfactory action to hinder normal operation.

Occasionally, when perfect alignment of the galvanometer has been made, the pen will not deflect at all when the Recorder is turned on. Generally, however, it will deflect to one side and then, within the space of a few seconds, will bob back and forth a few times and quickly come to rest. This means that the "Follow-Up Element" (see scale in unit "C" diagram No. 1), which has direct control of the pen's movements, is settling to its proper alignment with the position of the galvanometer coil, termed "tracking the galvanometer."

No. 6 Center pen with "Manual" setting of Centering Control.

Turn the Centering Control from "OFF" to "Manual" toward the left. If the Recorder "OUT" terminal leads to the galvanometer have been connected with the correct polarity, the pen will return to zero from whatever other point it may have come to rest. The operator has no means of determining the correct polarity except by the "trial-and-error" method. Should the "Manual" setting of the Centering Control cause the pen to deflect to one side of the chart paper and stay there, turn the Recorder switch off, reverse the "OUT" terminal leads and start again with step No. 2.

If the operator failed to hold his fingers sufficiently close to the pen, it may have deflected far enough to crash into an inner contact point, with the result that the high speed motor is running. In such case, it is necessary to press the Slow Chart button to stop and disengage the signature motor after the pen is returned to zero.

No. 7 Open shunt switch.

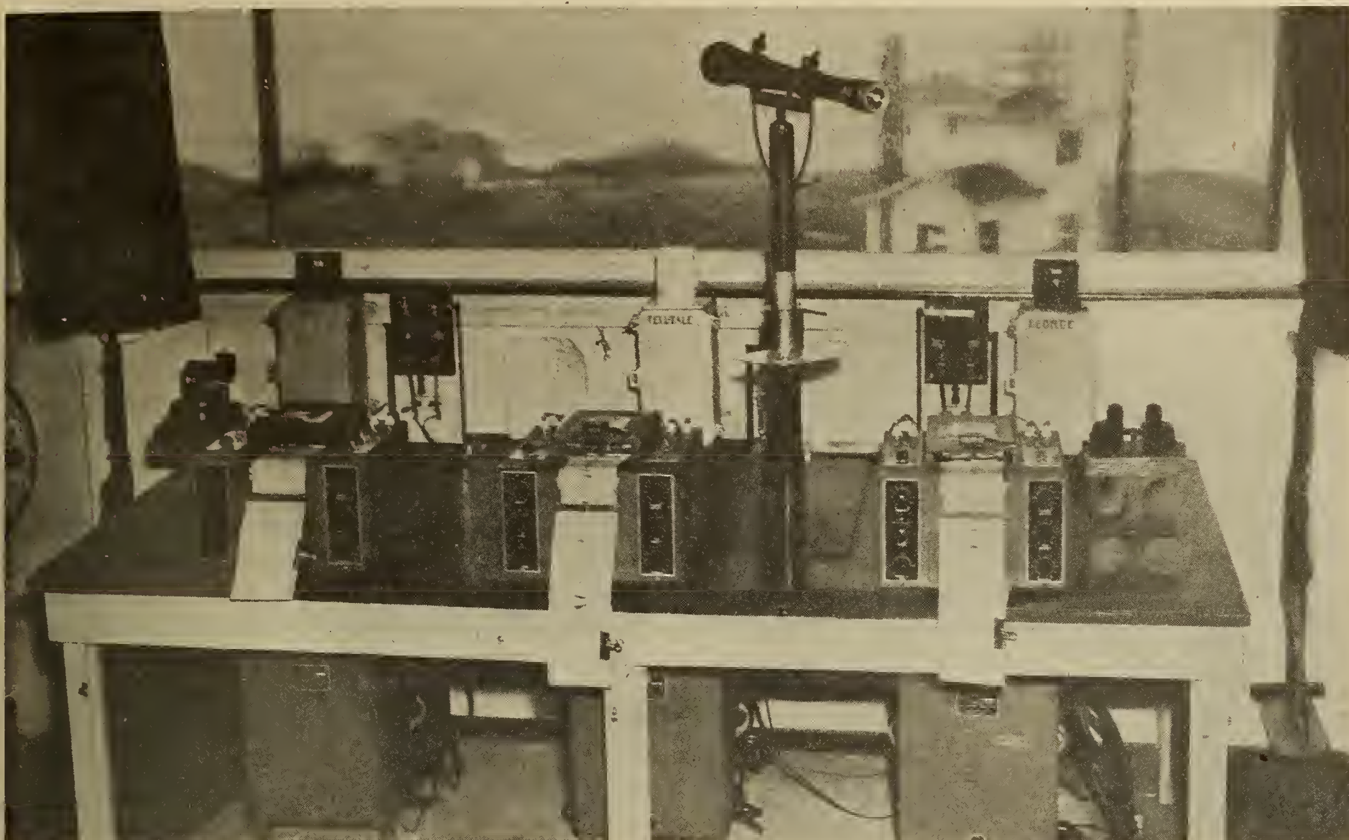
To protect the unit from any induced electromotive-force from the Loop while not in regular operation, there should be a shunt or shorting switch, used also for certain adjustments, across the leads fom the Loop. This can be a knife switch affixed across the Recorder "IN" terminals or some other suitable all-copper switch attached to the bulkhead or at some other convenient point ahead of the "IN" terminals. Any signature electro-motive-force can now enter the unit after the shunt switch is opened.

No. 8 Turn Centering Control to "Automatic" position.

This must always be at "Automatic" for operating.

No. 9 Place Sensitivity control to proper setting.

This control serves to establish the ratio of deflection between the galvanometer coil and the Recorder pen. It magnifies the galvanometer deflection into a larger scale pen deflection to obtain more easily read



Three Fluxmeters and recorders are in operation in the above picture at a harbor detection station on the east coast of the United States.

signatures. The operator will now turn it up to the setting at a point between "0" and "10" already determined by the watch officer or materiel man. The unit is now ready to record properly any signatures of ships crossing over the Loop.

To measure accurately the number of lines cut when a signature is made, the operator must now determine the operating sensitivity of the unit, so now:

No. 10 Make calibration.

This measurement of operating sensitivity has been provided for by installation of a constant-value flux cutting unit in the Recorder to simulate the action resulting from a ship crossing the Loop. It is named the Kilomaxwell Turns unit and is located at the bottom of the left face panel. Turning the control revolves a small permanent magnet inside a coil of wire, the coil conductor cutting the lines in the magnet's field to induce an electro-motive-force, causing the pen to deflect. The unit is so designed that 20,000 flux lines are cut when the magnet is turned one full revolution.

A calibration signature, with Sensitivity control setting at "5" is shown in diagram No. 2 starting at point "A" where the pen rested at zero, and finishing at point "D". This signature, with a curve on each side of zero, results from turning the control clockwise one complete revolution. To obtain the proper magnitude of signature rotate the control in a steady smooth manner at a speed of 4 RPM (15 seconds for the full revolution) so that neither friction of the pen against the chart paper nor excessive momentum of the pen will distort the size of the resulting curves.

The sample calibration signature shows the pen coming to rest at point "D" not quite back to the zero line illustrating the result of turning the control too slowly. From points "D" to "E" marks the course of the pen making its natural drift toward the zero line. At "E" a straight lines goes directly to zero, this being obtained by turning the Centering Control to the "Manual" position which causes the pen to return immediately to zero from whatever other point it may have been ,after which the Centering Control is returned at once to the operating setting of "Automatic." Whenever and for whatever reason the pen is brought to zero in this manner the resulting line on the chart is identified by marking it with an "X" and time entry, as every mark of the pen must be identified and accounted for.

Oftentimes the pen does not return to the zero line

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following a ship's signature, in which event it is necessary to center it with the "Manual" setting of the Centering Control, but always permit the pen to drift, if away from zero, for two minutes after each ship's signature so that you will not distort the signature of a submerged enemy submarine which might be trying to sneak entry behind a friendly surface ship.

Returning to the calibration calculation, let it be assumed that the sample signature curve shows proper speed of turning the Kilomaxwell Turn control and that the pen reaches its deflection peaks at 28 mms. to the right of zero and at 32 mms. away from zero on the left-hand curve. Since the full course of the pen's deflection in both directions was caused by the electro-motive-force induced through turning the Kilomaxwell Turn control, the operator knows that the total deflection of the pen is the sum of 28 mms. from zero to the peak of the right-hand curve plus 28 mms. from that peak back to zero, plus 32 mms. to the left hand peak plus 32 mms. from that peak back to zero, a total of 120 mms. By dividing this figure into the 20,000 lines cut, it is determined in this instance that 166 lines are cut to result in each millimeter deflection the pen makes. This establishes a known unit of measure against which to compare the magnitude of the pen's deflection ("maximum deflection") on a ship's signature.

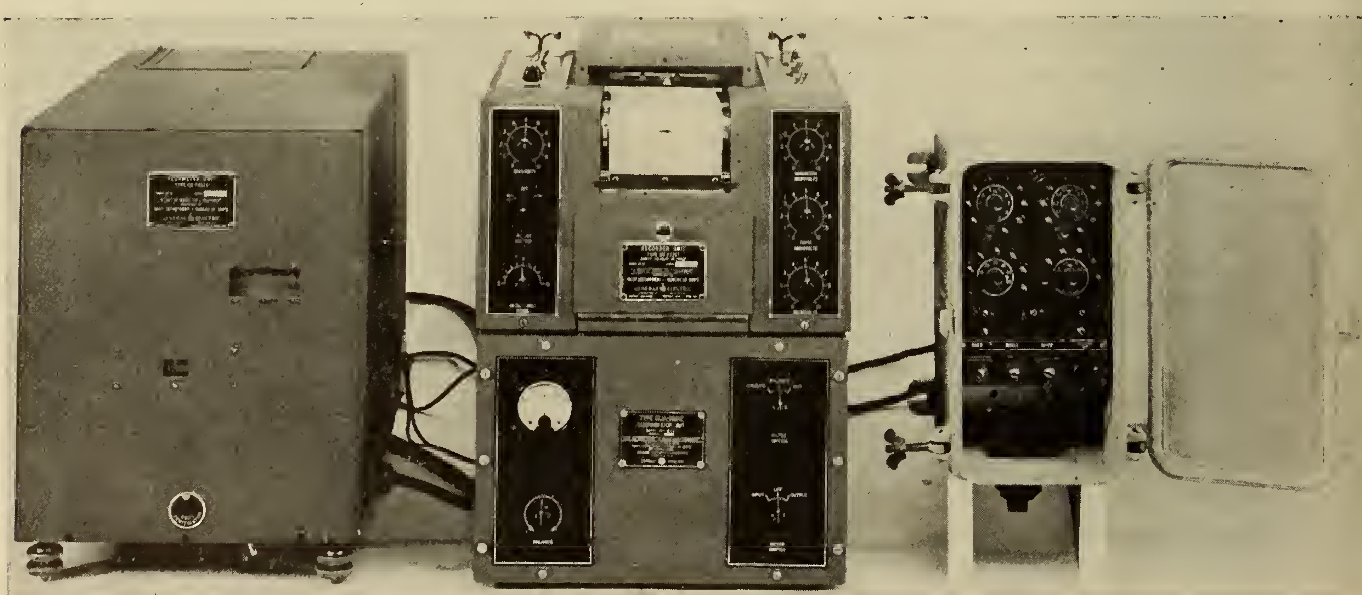
To speed up the calibration calculation so that full data is available for starting the watch with the least possible delay, the procedure is simplified by merely taking a direct reading in mms. of the pen deflection to the peak point on each side of zero. The peak points being 28 mms. to the right and 32 mms. to the left of zero, the operator simply adds these two figures together (60 mms.) and divides into 10,000 instead of 20,000 lines. Since only one-half the total pen deflection is used in the calculation, it naturally is necessary to divide into one-half the total lines cut in order to arrive at the same result as would be determined by using the actual total figures in each case.

Before logging the figure 166 (or whatever other figure results) it is necessary at this point in the calibration to take into consideration one more item having a bearing on the relative sizes of ships' signatures.

This item is the "Multiplier" setting listed in section "B" of Diagram No. 1. The Multiplier, included in the resistance balance box in all but the earlier Fluxmeter models, consists of a unit containing separate coils of electrical conductor wires, each with different resistance values which actually serve as "voltage dividers" and control the proportionate amount of the electro-motive-force induced in the Loop which is permitted to enter the Fluxmeter unit and be handled by it.

The terminus of the primary Loop circuit is at the balance box where enters a lead from each leg of the Loop. Here the outer and inner legs are tied together by electrical connection to properly complete their part of the circuit, and then only two leads leave the balance box for the remainder of the circuit. One of the two leads goes directly to one of the recorder "IN" terminals and the other passes first through the Multiplier and then to the other "IN" terminal. The Multiplier unit contains five possibe settings designated as 1, 5, 25, 125, and 625. These figures denote the ratio between the Loop electro-motive-force and the amount of electro-motive-force admitted to the meter.

The Multiplier circuit is explained fully in another



Discriminator unit with OS–1 fluxmeter and recorder.

section. The practical results are that if the number 1 setting is used to link the Loop with the inside unit the meter accepts the full electromotive force induced in the Loop; at the number 5 setting the unit receives only one-fifth of the Loop electromotive force (the other four-fifths being dissipated over the voltage divider resistor); at the number 25 setting the operator handles only one-twenty fifth of the Loop electromotive force in the shore unit; and, so on to the number 625 setting. Compared to a quantity of water flowing through a pipe, it is equivalent to either accepting the entire flow at the number 1 setting or tapping off any of the lesser designated proportionate amounts provided for in the specified settings of the Multiplier. The Multiplier setting is determined by conditions existing at each station location, particularly as to the depth of the Loop and the general size of traffic over it.

Obviously if the Multiplier setting is at 5 so that only one-fifth of the Loop electromotive force is recorded the resulting signature will be only one-fifth the size it would be if the full electromotive force were received. It would therefore be necessary to magnify each signature to five times its recorded size to arrive at the correct gauge of the size of the ship making it. Since the value of the detection job depends largely upon the speed with which can accurately be reported on all traffic, the operator now merely multiplies the calibration figure of 166 by the Multiplier setting to give a single operating sensitivity figure to apply against each ship's signature as actually recorded. This eliminates the otherwise necessary extra operation of multiplying the size of each signature by the Multiplier setting before applying the calibration figure.

The correct formula for calibration of operating sensitivity now reads:

10,000 (flux lines)
mms. (one-half total pen deflection in Calib. sign.) X Mult. setting = "Operating sensitivity".

Using the figures already quoted the formula reads:

$\frac{166}{1 \text{ mm.}}$ X 5 = 830 lines per mm. deflection of Recorder pen on a ship's signature.

On Fluxmeter signatures the operator is allowed up to only 30 seconds from the time the signature ends until full report must be made. A half minute or less would appear to be hardly adequate time for making the required calculations and transmitting the report but the operator will find that with conscientious study and practice he can easily complete the job within the specified time limit.

As soon as the operating sensitivity figure is determined, enter it alongside the word "Calib." already entered on the chart in the calibration signature curve as shown in diagram No. 2.

It is necessary to caution the operator against confusing the figures representing the "Sensitivity" control setting and the "Multiplier" setting in determining the operating sensitivity. At no time is the figure for the Sensitivity control setting used in the calculation. Only the Multiplier setting figure becomes a factor in the formula. The size of the calibration signature curve will vary with different sensitivity control settings. He merely has to remember to set up the Sensitivity to the designated setting before calibrating with the Kilomaxwell Turn control, leave it there, and then forget the Sensitivity control figure.

To answer questions which may have arisen concerning manipulation of the Kilomaxwell Turn control it might be well to explain the unit further. In question and answer form, the following is presented to clear up any such points:

(A) If the Kilomaxwell Turn control is turned one complete revolution, does it matter in which direction it is turned or from what point the rotation is started?

(1) The control can be turned in either direction. It is specified as in a clockwise direction only for the sake of uniformity.

(2) The setting of the Kilomaxwell Turn knob is merely a matter of choice. On the face panel behind the knob are the numerals "0" at the left axis point, "5" at the top mid-point, and "10" at the right axis point. First of all, the magnet should be set as closely as possible to a neutral position inside the coil so that an equal number of flux lines are cut in either direction of turn. Then the knob can be fastened with its set screw at whatever point is desired. Symmetrical appearance of the panel and controls can determine this setting. Afterward the rotation should always be started from the point selected and continued back around to it; for example, from 5 around to 5 again.

(B) Why does the sample calibration signature curve show pen deflection of 28 mms. outward in one direction from zero and 32 mms. outward in the opposite direction instead of an equal value deflection in either direction? Why must the control be turned a full revolution? Could we not turn the control either one-quarter or one-half revolution and divide the resulting number of mms. of pen deflection into 5,000 or 10,000 lines respectively instead of considering the full cycle curve of the pen and the full 20,000 lines cut in a revolution turn?

(1) In the first place, it is almost impossible either to set the magnet in a perfectly neutral position within the coil or to start turning the control from exactly the same point each time or to return it exactly to the same point.

(2) Therefore a quarter turn of the control might not cut exactly one-fourth of the 20,000 total. Perhaps 4,500 lines might be cut in one quarter of a turn and

5,500 in another, or 4,500 in a quarter turn in one direction and 5,500 in the opposite direction. Obviously, then, it is necessary to make a full revolution turn to be certain of accuracy in cutting 20,000 lines. As already explained, you determine whether the rotation was completed at the proper speed by observing whether or not the pen is returned exactly to zero.

(3) With an unequal number of lines being cut, the pen deflections on opposite sides of zero will not be equal. Hence, to calibrate the instrument accurately we should add the total mms. of deflection and divide into the total of 20,000 lines cut. The pen deflection outward from and back to zero being equal on the same side of zero, we can speed up the calculation by simply taking two readings, from zero to the peak of each curve on each side of zero, add together only two figures instead of the four figures for the actual total pen deflection, and divide the result into 10,000 lines, which, is equivalent to one-half the number of lines cut.

No. 11 Enter Chart Data.

Five additional entries are now made on the chart to complete its record of either a new watch starting or a change of watch. These entries, as listed in diagram No. 2, serve to:

(1) Identify the Recorder and Fluxmeter unit in operation.

(2) Identify the Loop to which the particular Recorder is attached and on which the operator is standing a watch.

(3) Record the Sensitivity control setting.

(4) Record the Multiplier setting.

(5) Record the amount of the Injected Voltage with also an arrow to show its direction.

The Injected Voltage (from a 1.5 volt dry cell battery inside the Recorder) is for the purpose of maintaining the "resting" or "idling" course of the pen on the zero line of the chart when no signature is being recorded. It compensates for and off-sets an idling course slightly away from the zero line. The galvanometer adjustment might not be quite at its exact zero position, with the result that the pen assumes a like position away from the chart zero. If the distance from zero is only slight, it can be corrected by injecting up to a few tenths of microvolts into the galvanometer coil circuit in such direction as to hold the resting position of the coil exactly at zero. In this manner it is possible to continue satisfactory watches without interruption for only a slight adjustment of the galvanometer zero.

All switches and controls below the power switch on the right side of the Recorder case are included in the Injected Voltage circuit. The first switch marked XI–X10 indicates that either a direct reading can be taken of the microvolts dials if the switch is in the XI (times one) position, or that the reading be multiplied by 10 if in the X10 (times ten) position. The X10 position is occasionally used for certain adjustment purposes, but if it ever becomes necessary for the operator to use it to obtain a balance of the instrument, it will indicate that there is probably some trouble which requires the attention of an officer.

The next lower switch marked with a directional arrow on each side shows the direction in which the voltage is injected to bring the pen to zero. It is placed in the right hand position if the pen rests slightly to the left of zero, and to the left position if correction in that direction is desired. Note that the switch is thrown in the direction the operator wishes to cause the pen to move.

The top microvolts dial is from 0 to 10 in units of 100th microvolts, the next from 0 to 10 in 10ths of microvolts and the third from 0 to 10 in units of microvolts. Each of these three control settings is independent of the others and therefore it is necessary to add the sum of the three readings to determine the total amount of injected voltage.

As shown in Diagrams Nos. 1 and 2, the injected voltage is in the amount of .02 microvolts toward the left. If, instead, the lower control were at 1, the middle control at 3, and the upper control at 4, the total injected voltage would be the sum of 1. — .3 — .04 or 1.34 microvolts. However, as previously indicated, a satisfactory operating condition would not be obtained if more than a few tenths of microvolts were required to hold the pen at rest on zero. The larger values of injected microvolts are available for adjustment purposes as required from time to time.

Until the operator receives instruction in maniuplation of these switches and controls during the latter period of training, he will not change any of the settings but will take their reading for recording on the chart. If any settings are changed by the watch officer or materiel man during his watch or later by himself, he will record on the chart the change and the time it is effected, opposite the point of the pen when such change is made.

No. 12 Enter log data.

Various local conditions at a harbor detection base will require that different types of log forms be used. The operator will undoubtedly log such data as is listed on the Recorder Chart plus details concerning each signature, to serve as a record of communications reports on traffic observed during his watch. All log entries must be made immediately following each activity and will tie in with signature entries and other such data on the chart paper. Probably the reports to patrol craft on signatures will cover only the approximate size and speed of ships crossing the Loop, but additional entries will be made in the log on such items as the probably direction of travel and the type or types of magnetic fields about the ships so that amplifying details can be given if needed.

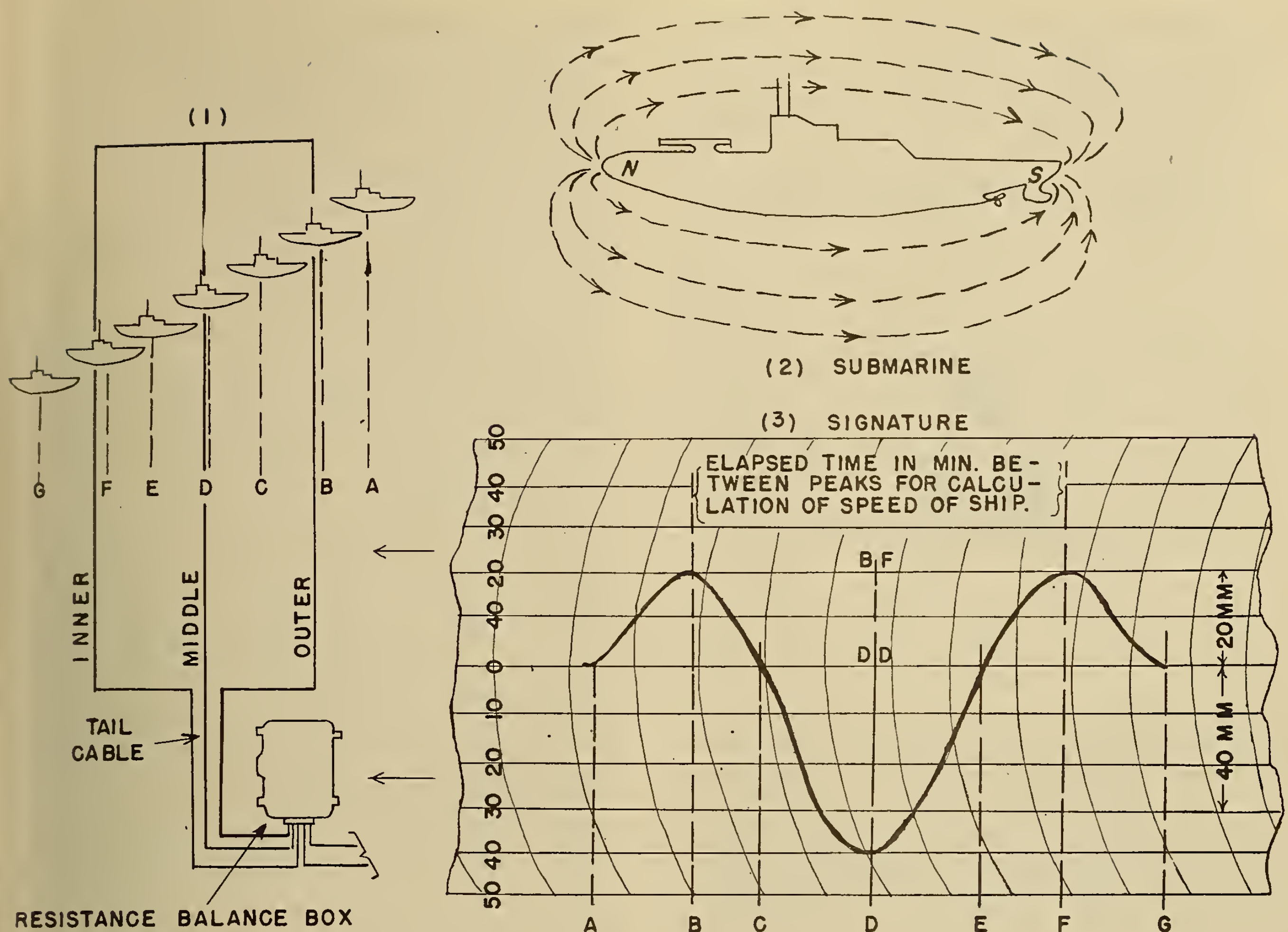


Diagram 4.

STARTING RELIEF WATCHES

The 12 steps just covered must be carefully followed in the exact order listed each time a Fluxmeter unit is placed in operation, either when first installed or when switching to a stand-by unit. After once in service, however, the meter will of course be in operation 24 hours per day and subsequent watch changes will require only repetition of steps Nos. 1, 10, 11, and 12.

Step No. 1 will not require the relief operator to draw a line across the chart from the point of the pen, as the operator going off watch will do this and sign "OFF" with his initials, name, and hour of watch change beneath the line. The relief operator will then merely sign on above the line. New calibrations will probably be necessary only about twice each week to check for a change in operating sensitivity. The chart and log data entries must be made at each watch change.

ANALYSING SIGNATURES

Diagram No. 4 gives (1) a model Loop, (2) picture of horizontal magnetic field about a ship, and (3) sample of the signature its crossing would cause to be recorded. The letters A to G inclusive in (3) show the respective parts of the signature curves recorded as the ship crosses relative parts of the Loop.

While the chart paper will actually unroll from the Recorder directly outward toward the operator when facing the Recorder, signature samples are shown as progressing from left to right for convenience of comparison.

Remember that the pen does always return completely to zero at the end of a signature. This requires: first, that the operator permits the pen to drift two minutes

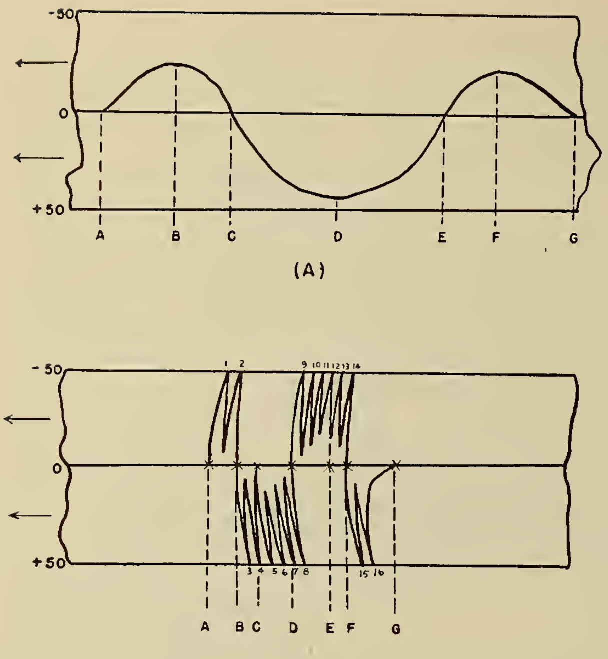


Diagram 5.

at high speed so that he can instantly note the attempted sneak entry of a submerged submarine perhaps with a very small signature, and, second, that he marks the chart with an X and time entry when the pen is brought to zero with the "Manual" setting of the Centering Control after two minutes have elapsed. After centering the pen, press the Slow Chart button to disengage the high speed motor.

Application of the principles discussed in the fundamental electricity and Loop theory courses, logically explains the tracing by the Recorder pen of deflections caused by an electromotive force induced in the Loop legs as they cut the flux lines carried over them by the ship. Compare the ship with a bar magnet having only horizontal magnetism in this instance, with the North pole forward. Flux lines are shown leaving the North pole and re-entering at the South pole. If the ship is moved forward over the Loop, the lines in the lower half of the field extending down into the water will be cut by each of the Loop legs, first downward at the fore parts and upward at the after part of the ship. The induced electromotive force will be first in one direction and then in the other, and will be recorded by the pen moving to first one side and then the other in line with the direction of electromotive force which causes the deflection.

The changing polarity of the induced electromotive force will cause the galvanometer coil to deflect first in one direction and then in the other as each leg is crossed. The follow-up element follows or "tracks" the galvanometer coil deflections causing exactly duplicated and magnified movements of the Recorder pen which, in turn, leaves its written record of relative deflections.

Hence the signature has three distinct curves, one for each leg of the Loop. Points A through B to C represent the curve for the ship's crossing over the outer leg, points C–D–E over the middle leg, and points E–F–G over the inner leg. The Loop circuit is such that only one-half the electromotive force induced in the outer or inner legs reaches the galvanometer whereas the full electromotive force is received from the middle leg. This results in the first and third curves being half as great in size as the middle or second curve.

In this simple and basic type of signature, the middle leg deflection of the pen from zero (D–D) to D is twice the outer and inner leg deflections from zero to B or from zero to F. Hence the mm. value from D–D to D will be twice the mm. value from D–D to B–F on a line from B to F.

Starting with ship position A where it is just approaching the outer leg, compare corresponding points of the signature again. At A, lines in front of the ship in a downward direction are being cut, an electromotive force in one direction is induced, and the pen starts to move away from zero. At B, the pen reaches the peak of the first curve as the middle of the ship moves over the outer leg. At this position of the ship, the flux lines are running parallel both to the lengthwise axis of the ship and the plane on which the Loop leg lays, with the result that the lines are sliding over the conductor instead of being cut by it, no electromotive-force is being

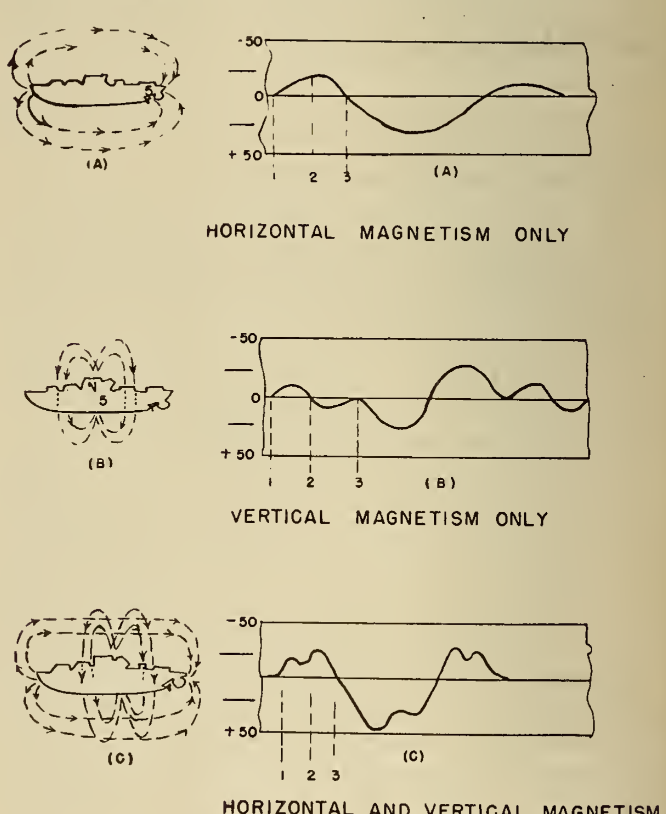


Diagram 6.

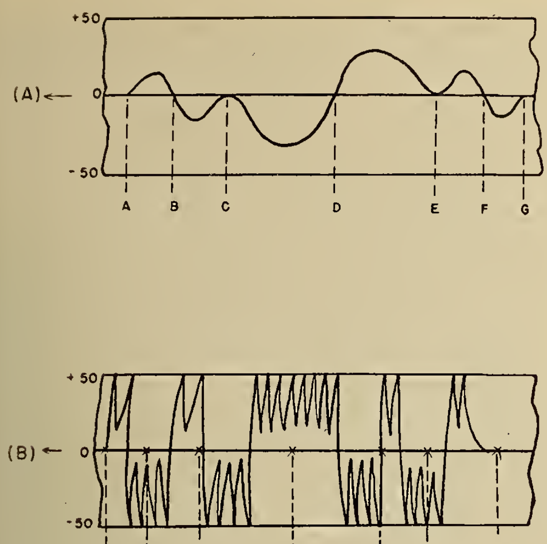


Diagram 7.

induced, and the pen does not deflect either away from or toward zero for a brief moment.

As the ship draws away from the outer leg, lines are again cut but now in an upward direction with the result that the electromotive force is of the opposite polarity and the pen moves correspondingly in the opposite direction until it reaches zero at C with the ship between the first two legs where again no lines are being cut. Exactly the same result is obtained as the ship crosses the middle and inner legs except that the first deflection direction over each of the last two legs is opposite to the first deflection direction over each preceding leg with the resulting curve described by the pen being in the same continuous direction from the peak of one curve to the peak of the next. The curve from C to D corresponds to the mid-point of the ship drawing up to the middle leg, from D to E drawing away from the middle leg; from E to F approaching the inner leg, and from F to G drawing away from the inner leg.

Whether the pen deflects first to the left or to the right of zero as a signature starts depends entirely on the polarity of the electromotive force which starts the first deflection. It is immaterial to the analyzation of a signature whether the first deflection direction of the pen is to the right or to the left, in view of the facts that the respective curves will be relatively equal in magnitude, they will form the same pattern in relation to each other, and the over-all length of the signature will be the same.

One ship might have its magnetic field in opposite polarity to another and the polarity of the same ship can be reversed. A new ship under construction draws a magnetic field about itself by attracting lines of flux from the earth's magnetic field to the magnetic materials in the ship, the polarity depending upon the direction of the ship in relation to the earth's magnetic North, while being built. Also a ship travelling a long distance in one direction will either add to the strength of its established field or the field will be cancelled and another of opposite polarity built up, depending upon its course of travel in relationship with the earth's flux polarity. Still other changes can be effected by use of electrical equipment to alter or cancel permanent fields about a ship.

Since the Recorder pen's first direction of deflection to either left or right of zero depends upon the field polarity, the signature does not tell which outer leg is crossed first by a ship. The signature's first direction of deflection (right or left) would be the same on a ship inbound North pole forward as an outbound ship South pole forward. An inbound ship with North pole forward would cause the first deflection to be in the opposite direction to that on the same ship outbound with the North pole again forward. Nevertheless an accurate log can be kept on all ships crossing within visual range of the operator's own station, or of a nearby observation post, and in a short time determine the percentage of, say, inbound traffic which causes the first deflection in the same direction so that he can "guess" correctly at least more than half the time on the probable direction of travel of unobserved ships. This might at times be a very important factor in enabling patrol craft to do their job efficiently.

Neither does the operator have any means of accurately determining the course or bearing of a ship from the signature, but he can definitely tell when a ship crosses the Loop, and can fulfill his mission by quickly reporting ship traffic, friendly or otherwise. The Harbor Entrance Control Post to which reports are made has a log of all traffic authorized at any particular moment, and if the operator reports the presence of a ship not authorized to be in the area at that time, it obviously follows that patrol craft is sent out to investigate and to attack if necessary.

Now as to the reports which are generally made on the estimated size and speed of recorded traffic. The size estimate of the ship is reported in approximate number of flux lines cut. We have already calculated the unit's operating sensitivity as being 830 lines cut per millimeter deflection of the pen, in the example quoted. By applying this figure against the maximum number of mms. deflected by the pen the operator determines the total number of lines cut. Since the reading would naturally be taken at a point where it is known that the ship is crossing the middle leg from which the full electromotive-force is received from the Loop, the operator simply reads the number of mms. from zero on the chart to point D, the peak of the middle leg curve, where the pen moved farthest away from zero.

[redacted]

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This deflection distance (40 mms.) is termed "maximum deflection" and completes the formula:

Operating sensitivity X max. deflection = Total lines cut. By substitution:

830L/mm. X 40 mms. = 33,200 lines.

Since the total lines cut represent only on approximation of the size of the ship the operator reports only in even thousands, such as 33,000 in this case or 34,000 if nearer to the larger figure. The Officer in Charge at the station may prefer that reports be made in several general size classification such as large, medium or small ships.

Signature sizes for traffic over the East channel practice Loop at the San Pedro, Calif., station range from approximately 10,000 to 1,500,000 lines. The size of the signature depends solely upon the strength of the ship's magnetic field, which means that a small ship with strong magnetic field would give as large a signature as a large ship with a weak field. In addition to factors already mentioned, the magnetic field strength will vary with the amount and type of metal in the ship's cargo. One freighter of a certain type may show 375,000 lines whereas another of the same type may show 525,000 lines, a difference of 150,000 lines.

The operator should not let this seemingly large discrepancy in accurately estimating ships' sizes tend to disillusion him or to cause any lack of faith in the equipment. It has definitely been proved that the meter will very faithfully record all traffic where there is enough metal in a ship to attract even a light field of magnetism. Naturally an all-metal submarine will, for example, give a good size signature. In some areas it is easy to record easily read signatures on wooden fishing boats containing only the metal in their small engine power plants.

The one other generally reported item is on the approximate speed of the ship. Although here, likewise, the operator must arrive at only an estimate, since the ship's course and bearing is not known, he can state definitely how long it takes the ship to cross from one outer leg to the other. With signature points B, D, and F corresponding to mid-ship crossing over each leg of the Loop, it is easy to determine the elapsed crossing time by reading in minutes the signature time between points B and F.

Speed is calculated in the formula:

$$\frac{12}{t\ (\text{Time in mins. from B to F})} = \text{Speed in knots.}$$

This formula is arrived at by applying the fractional part of an hour required for the crossing, against the fractional part of a nautical mile covered by the over-all width of the Loop. A nautical mile contains 6,080 feet

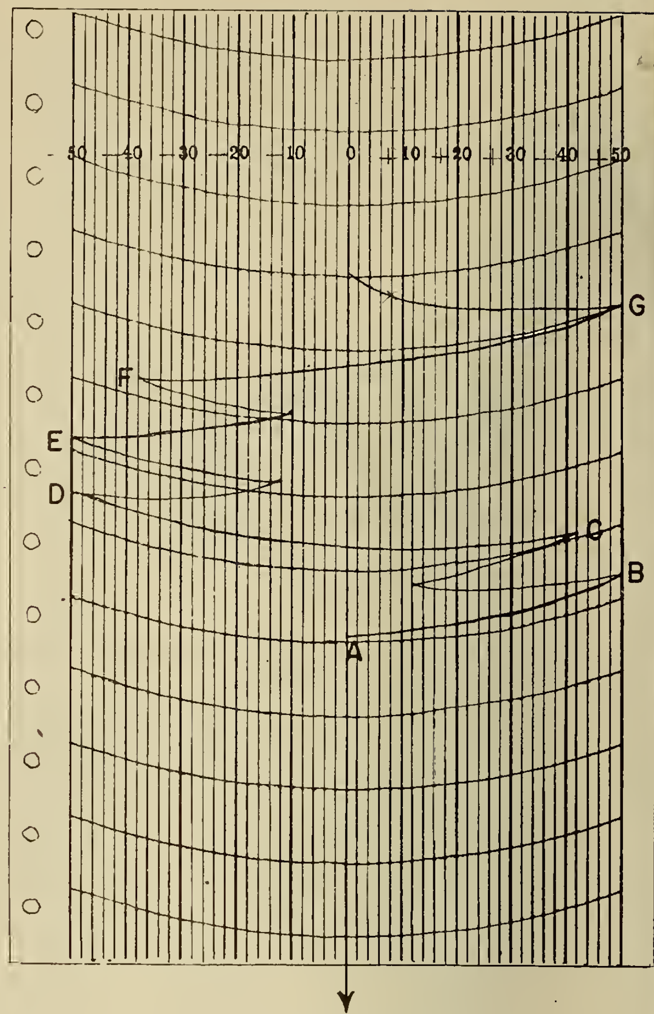

Diagram 8.

(1 minute of longitude at the equator) or 2026.7 yards. It will be satisfactory to use round figures of 2,000 yards in view of the fact that the speed calculations is only an approximation. The formula now develops as follows:

$$\frac{60\ (\text{mins. in one hour})}{t\ (\text{Elapsed time from peak B to peak F})} \times \frac{\text{Loop width}}{1\ \text{naut. mile}} = \text{Speed in kots,}$$

By substitution:

$$\frac{\overset{12}{\cancel{60}}}{t} \times \frac{\overset{1}{\cancel{400}}\ \text{yds.}}{\underset{\underset{1}{\cancel{5}}}{\cancel{2{,}000}}\ \text{yds.}} = \frac{12}{t} = \text{Speed in knots.}$$

Thus if there were exactly four ½ inch chart paper divisions from peak B to peak F on Diagram 4 signature, and each ½ inch division represents passage of ½ minute in time, it is known that it took the ship two minutes to travel from one outer leg of the Loop to the other. By substituting 2 for the divisor t in the formula the operator determines the speed as $\frac{12}{2} = 6$ knots.

Probably another station Loop or Loops will be this same width, but if not, the operators can establish a new speed formula by substituting for the 400-yard figure the over-all width of the Loop.

The type of signature just discussed may be considered as the basic curves from which are developed all other types of signatures. Next it will be seen how the same type of signature appears on a much larger scale, when a greater number of flux lines are cut, and then other types of signatures will be developed.

Signatures (A) and (B) in Diagram 5 show first a reproduction of the diagram 4 signature and then the same signature magnified to five times its original size.

To make a direct comparison between the two signatures, merely apply the rules; that the direction of deflection of the pen will continue the same as long as the induced electromotive force which started the deflection is of the same polarity, and that when the polarity of the electromotive force changes, the direction of pen deflection will also change. Hence, in signature "A" the curve from points A to B is drawn as the result of the first electromotive force polarity, from B to D shows the result of change in electromotive force to the opposite polarity, which reverses again from D to F, and still again from F to G.

To understand the difference in appearance of the magnified signature "B" it is necessary only to consider the additional fact that when a signature curve, or pen deflection, is of sufficient magnitude to carry the pen to the outer limit of the chart paper the pen is each time instantaneously "bumped" back to the zero line to resume its same directional deflection away from zero as long as the electromotive force continues in the same polarity. This results in portions of the signature being "folded" back to the common starting line at zero.

Magnifying the smaller signature five times would result in increasing the first polarity deflection of A to B from 20 mms. in "A" to 100 mms. in "B", and since the pen can travel only 50 mms. at a time away from the zero line it is required to record that polarity electromotive force in two full scale deflections on the same side of zero in "B". Since the pen is bumped back to zero each time it reaches a full scale deflection, it comes to rest momentarily on zero at point B while no electromotive force is being induced in either direction. Point B at zero in signature "B" corresponds to B at 20 mms. away from zero in signature "A". The lines drawn by the pen in returning to zero each time from full scale deflections do not represent any deflection value since they merely describe the path of the pen's course in being bumped back to the zero line. Accordingly, the two "bumps" in the first group of bumps, on the same side of zero (counted at the outer edge of the charter paper) multiplied by the 50 mm. value of each bump represent the 100 mm. deflection half way across the first leg of the Loop.

At point B in both signatures the electromotive force polarity changes so that in "A" the curve to C results in the pen returning toward zero from the 20 mm. peak at B and in signature "B" the pen crosses to the opposite side of zero and describes two full scale deflections in bumps numbers 3 and 4. Since the polarity of electromotive force does not change at point C the pen stays on the same side of zero in signature "B" to inscribe curve C to D in the magnitude of 200 mms. (5 times 40 mms. in signature "A") represented by four bumps. This results in a group of six bumps in the second group, all on the same side of zero to picture the one directional electromotive force from B to D.

The remainder of signature "B" follows the same pattern but in reverse order. Curve D to F is magnified into six bumps of which four bumps represent the 200 mm. deflection corresponding to curve D–E and two bumps (100 mms.) for curve E–F. Curve F to G then is completed in two bumps on the opposite side of zero.

"A" is designated as an "unfolded signature" which is the term used to describe any signature whose curves are contained within the 50 mm. limit on each side of the chart paper zero. When the magnitude of any of the curves carries the Recorder pen to a full-scale 50 mm. deflection in one direction from zero, the pen is driven instantly back to the zero line to start another deflection outward in the same direction. This results in a signature appearance such as in "B" which is termed a "folded signature".

The curves in all "unfolded signatures" will not conform to the smooth regular curves such as in "A". They may be irregularly spaced with fairly sharp peaks which depict different types of magnetic fields; but, at no time during the course of the signature will the pen reach a full scale deflection. A "folded signature" may likewise show values and combinations of different magnetic field components but all "folded signatures" will have the same characteristic of the pen reaching maximum limit of deflection in one direction resulting in its being bumped back toward the zero line.

The following rules apply to the analyzation of any signature, whether or not they conform to the characteristics of "A" and "B":

1. In any signature the pen's curve will continue in one direction as long as the polarity of electromotive force remains the same as that which started the deflection in that direction.

(*a*) In an unfolded signature the curve in one direction may cross zero as from point B to point D in signature "A".

(*b*) In a folded signature the lines will all be one one side of zero as long as the electromotive force is in the same direction such as from points B to D in signature "B".

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2. In any signature, the direction of pen deflection will reverse with change in polarity of electro-motive-force. The pen may or may not cross the zero line in either a folded, or unfolded signature, depending upon whether the deflection in the reversed direction is of sufficient magnitude to carry the pen to and beyond the zero line from whatever point it started when the polarity changed. However, in a folded signature if the pen does cross zero it will continue deflections on that side of zero until the polarity changes again.

Discussion of folded signatures up to this point makes reference to the pen being bumped back to zero at the end of each full scale deflection. Practically, however, the pen does not actually reach the zero line each time while the electromotive force continues in the same direction. This is illustrated in signature "B" of Diagram 5, and is explained by the fact that the Loop electromotive force offsets the momentum of the instantaneous bump back toward zero before the pen actually reaches the zero line and the same directional electromotive force again takes control to force the pen back toward the outer edge of the chart. The greater or lesser distance from zero at which the electromotive force surge counteracts the bumped momentum of the pen depends upon the rising and falling magnitude of Loop electromotive force at the more and less dense parts of the magnetic field.

The zero line in folded signatures carries the reference points for determining speed of crossing. In signature "B" the pen crosses zero at points B and F corresponding in signature "A" to the peaks of the outer and inner leg curves, and therefore the elpased crossing time is read from the point where the pen first crosses zero to the point where it last crosses zero.

The maximum deflection for size estimation in a folded signature is determined by counting the bumps or portions thereof corresponding to the deflection distance from zero to the peak of the middle leg curve in an unfolded signature. In signature "B", the four bumps numbers 5, 6, 7, and 8 correspond in signature "A" to the curve from points C to D at which latter point the maximum deflection reading is taken. From zero to D in signature "A" is 40 mm. whereas in "B" the deflection distance for the same curve is represented by the four above mentioned bumps. As each bump indicates a full scale deflection of 50 mms. the maximum deflection becomes 4 X 50 = 200 mms.

Applying the sample operating sensitivity figure of 830L/Lmm., it is then determined that the total number of lines cut equals 830 X 200 = 166,000 flux lines.

Again review the first half of signatures "A" and "B" to prove this method of obtaining the maximum deflection figure. In "B", the first group of bumps (two in number) represent the initial electromotive force over an outer leg of the Loop and corresponds in "A" to the curve from points A to B. In "A" the pen returns an equal distance from peak B to zero at point C whereas in "B" the pen crosses zero, and it is therefore necessary to complete the second half of curve A–C in "A" by deducting from the second group of bumps in "B" an amount equivalent to the value of the first group of bumps. Subtracting the equal value of two bumps from the second group in "B" leaves the four-bump value for curve C–D and separates the one directional curve from B to D into the respective parts belonging to the second half of the outer leg curve and the first half of the middle leg curve.

Before proceeding with development of types of signatures differing from the two already covered, it would be well to discuss the reason for differences in the patterns of various kinds of signatures. The only difference other than in "size" lies in the effect of the combination of differently aligned magnetic fields about some ships. For one thing, a ship may not have simply a horizontal or a vertical magnetic field about itself but may have a combination of both, with like components adding to each other at certain points and opposite components detracting from each other at different points. Also, the relative strengths of these respective components vary. In addition, the fluxmeter frequently records the crossing of more than one ship over the Loop at the same time, each with perhaps differently polarized fields, varying combinations of fields, and different values for the strength of each component.

The various types of magnetic fields about ships would appear as in figures (a), (b), and (c) of Diagram 6. While figure (c) shows two separate fields for emphasis of the two component effect, the combination would actually appear as one distorted field since the two fields which are shown will add together at certain points and will cancel each other at certain points. Figures a1, b1, and c1, show the signature pattern of each. The appearance and analyzation of signatures involving crossing of more than one ship at a time will be covered during actual operating practice.

It has already been learned how a signature such as "a1" results from the crossing of a ship having only horizontal magnetism.

Ship "b" has only a vertical field concentrated along the axis line of the funnel and engines. In the case of horizontal magnetism the operator measures only the half portion of the magnetic field extending down into the water below the ship, whereas the ship "b" the magnetic poles are in a vertical position resulting in the Loop legs cutting both sides of the field as the flux lines leave (or enter) the pole extending downward. In the case of "a", there is recorded only one directional change in flux lines from, for example, downward at the bow to upward at the stern, whereas, in "b" there are two direc-

tional changes for example, upward near the bow, downward along the middle of the field, and again upward near the stern.

Remembering that a change in direction of the cutting of flux lines results in a corresponding change in direction of pen deflection, signature "b1" automatically progresses from points 1 to 3 with two directional changes from upward to downward to upward again as the ship crosses over the first leg of the Loop. From the peak of the first curve above zero to the peak of the first curve below zero is twice the distance of that from zero to the peak of the first curve on either side of zero due to the fact that the field density is twice as great in the center where the downward flux lines on both sides of the axis add to each other, whereas the upward lines are separated into their respective halves. In signature "b1" there are two opposite-wise curves on both sides of zero corresponding to one curve all on the same side of zero in signature "a1" for each leg of the Loop crossing.

Signature "b1" also differs from "a1" in that the first deflection direction for crossing of the second and third legs is in the opposite direction to the last deflection for the previous leg crossing.

Signature "c1" follows as a combination of "a1" and "b1" with the same directional electromotive forces adding to each other at certain points to effect sharper curve pen deflections, and opposite polarity electromotive forces off-setting or altering each other's values at other points.

Signature "b1", magnified in turn to five times its original size "folds" into the appearance of signature "b1" in Diagram 7. The operator is directed to call in the Watch Officer for consultation on signatures which do not conform to the patterns of signatures "A" and "B" in Diagram 5. First, however, make the preliminary report to H.E.C.P.

Affect on Signatures of Degaussing and Deperming

It is a war time practice to protect ships from enemy-laid magnetic mines by removing with electrical gear the vertical magnetic field and sometimes the horizontal field from about the ship in processes known as degaussing and deperming. The detonator of magnetic mines is actuated by deflection of a needle in the mine, the needle being deflected by the force due to the ship's field. The mines are planted by enemy submarines or aircraft with anchors which hold the mines at a depth below the surface level where they will cause the most damage by being detonated underneath the middle section of the ship.

Generally the vertical field is strongest directly below the ship and is the one most likely to set off the mine in the region where it will do the most damage. For this reason degaussing to remove the vertical component is most commonly practiced. A degaussed ship gives a signature showing only the remaining horizontal magnetic field, and a depermed ship's signature shows vertical magnetism in addition to the horizontal.

Unless this counter-effect-gear is permanently installed and operated, the ship will soon become magnetized again during the course of its travel. Thus, the large variation in signature patterns is caused in part by the different fields about ships and the many differences in respective values of the field's components.

Application of the rules already given in the explanation of these signature samples will make it possible for the operator to determine intelligently the magnetic field components in any type of signature and so analyze whatever activity may be indicated by the recording of traffic over the Loop. Determining whether the field components are contained in one ship or in more than one ship crossing at the same time will be further clarified in operating practice. Generally, an unfolded signature more easily pictures the crossing of a ship over the respective legs of the Loop and therefore the practice is to "unfold" a complicated type of "folded'" signature by reducing its size to a smaller scale copy in reverse order to the process covered in constructing a larger scale drawing from an unfolded signature.

Calibration at Higher Sensitivity Settings

Different settings of the Sensitivity control will result in various sizes of calibration signatures graduating from a total pen deflection of approximately 24 mms. at setting of "0" to approximately 360 mms. at the "10" setting. The formula already given for obtaining the operating sensitivity figure will apply in each case.

Application also of the rules given for determining distance of pen deflections in folded signatures will furnish the mm. divisor figure in the formula. Diagram 8 shows the signature of a calibration made at Sensitivity setting of "10" which results in the pen reaching several full scale deflections and being bumped back to "fold" part of the signature curves. The length of this sample signature is extended beyond the normal distance of a calibration made at proper speed of turning the Kilomaxwell Turn control. This is done to obtain greater separation between the signature curves fore easier comparison against the explanation of the deflection.

It is necessary to use extreme care in turning the Kilomaxwell Turn control to make certain that the operator stops the turn at the instant the pen touches either of the outer contact points. Hold the control stationary until the pen comes to rest at the point to which it is driven backward and then immediately resume the turn at the original rate of speed, continuing this procedure at each full scale deflection of the pen.

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Counting the millimeters of pen deflection proceeds as follows:

	Milli-meter
From zero point A at start of signature to full scale deflection point B	50
From zero to deflection point C	42
From C back to zero (by e.m.f. Polarity change)	42
From zero to point D	50
From zero to point E	50
From zero to point F	38
From F back to zero (another polarity change)	38
From zero to point G	50
Total	360

This reading of deflection distances departs slightly from complete accuracy in view of the fact that the pen is not bumped entirely back to zero from each full scale deflection. However, it conforms to ship signature analyzation and gives a simplified procedure to follow in arriving at a calibration figure which is sufficiently accurate to serve the purpose.

The operating sensitivity formula now develops in this instance as follows:

$$\frac{20{,}000}{360} \text{ X } 5 \text{ (multi. setting)} = 277 \text{ L/MM.}$$

The figure 277 lines per millimeter is then applied against the maximum deflection in a ship's signature to determine the total number of flux lines cut for estimate of the ship's size.

Communications Procedure and Station Logs.—Naval Radio-Telephone communications procedure will be used in transmission of all verbal reports. This procedure which is covered in a separate manual provides a simple and flexible means of communications which is in common use by both U. S. and British Navy and Army.

It is important that the operator studies the procedure carefully and be prepared to quickly handle any type of emergency transmission which might present itself. In all likelihood he will transmit messages for the Army and for other Naval units in addition to handling his own reports.

Particularly in view of the fact that part of his transmission will be by radio, it is necessary to caution him against the use of any profanity, to encourage brevity consistent with clarity, and to avoid use of unnecessarily complicated or unusual words or phrases.

Each detection device will probably require the keeping of separate logs, and there will also be a general log book at the station in which to make appropriate entries of general activities, musters, record of visitors, equipment inventories, replacement and repair reports, and any other items which should be logged. The type of forms to be used will be dictated by the needs of the station to which the operator is assigned.

LAYING CABLE FOR MAGNETIC DETECTION LOOPS

In "Instructions for the Installation and Maintenance of Submarine Cables and Seat Units for Harbor Detection Equipment" it is stated:

"The cable should not be laid so tight that it is lifted off the bottom at the low points. On the other hand very little slack should be permitted or the cable is likely to kink when underrun."

This instruction is correct for Herald, Cable-Connected Hydrophone, and Loop tail cables but experience has shown conclusively that there is considerable advantage to be gained by laying Loop cable carefully with the exact amount of slack.

In most locations the usable sensitivity of Magnetic Detection Loops is limited by perturbations due to cable movement. Probably most of the movement occurs in places where lengths of the cable are suspended between high spots on the sea bottom. If the cable is laid with the correct amount of slack it will conform closely with the bottom and the movement will be materially reduced. Ideally, the cable should be laid so that it is under no tension as it lies on the bottom. Some tension will exist as the cable leaves the ship due to the weight of the length hanging in the water. The configurations taken by the cable when layed correctly and incorrectly are indicated in Figure 3–4.

It should be realized that if the cable were paid-out rapidly enough so that it tended straight down, it would be impossible to tell whether or not it was piling up in coils on the bottom. In order to be sure that the cable

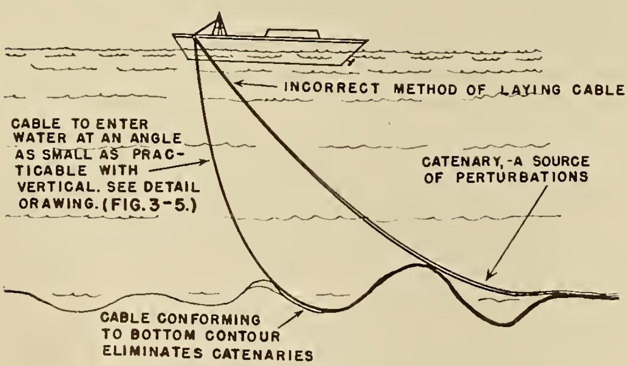


Figure 3–4—Method for laying cable.

is not piling up on the bottom, sufficient strain must be applied so that it tends slightly aft as it leaves the ship. Hence the criterion to be used in determining whether the cable is being laid properly is the angle which it makes with the vertical as it leaves the ship. This angle should be kept as small as possible. See Figure 3–5.

An additional precaution can be taken to avoid piling up of the cable on the bottom. If the marker buoys used to mark the cable course are spaced at known intervals, the length of cable paid out, as determined by counting the splices, can be compared with the actual distance run. It is to be expected that the length of cable laid over a given run will exceed the charted length of the run from 15 to 25 percent.

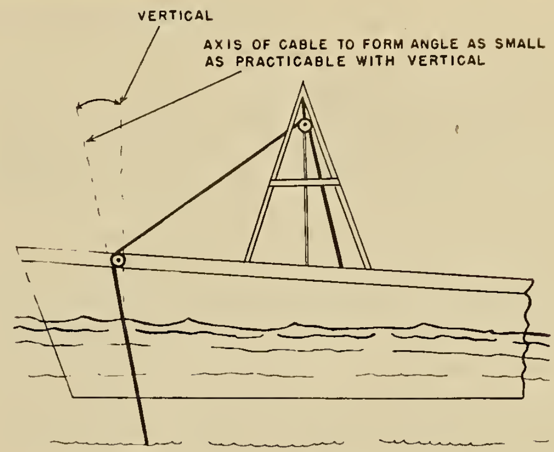


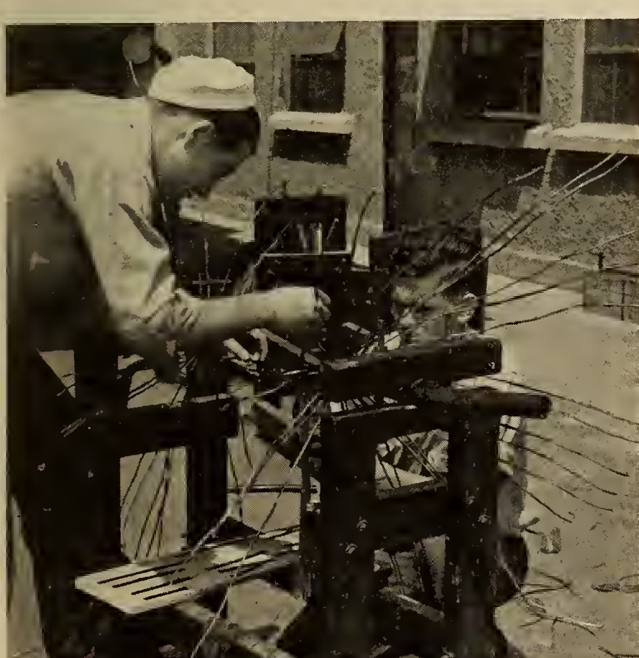
FIGURE 3–5—Details showing cable entering water.

Marker buoys could be spaced so that the distance between them is a measurement of the amount of cable required on the bottom. Recording fathometer charts help.

CABLE CARE

Harbor defense officers having cognizance of the loading, storage, and handling of cable should make certain that the personnel performing these tasks observe the following precautions:

Always roll cable reels on the ground so that the inside layers of cable are tightened. In other words, the pull should be applied to the end of the cable under the plate cover. Rolling the cable in the opposite direction will result in an accumulation of slack in the outer layer of cable. When this happens, the cable will rub and scrape against the lags and be damaged. Furthermore, when the lags are removed, the slack will fall on the ground and present an awkward problem in paying out the cable.



A "Y" splice, as is being made in the above picture, is one of the most important splices harbor detection personnel have to know.

If the reel is to be lifted, insert the steel axle through the holes in the drum. A sling looped around the axle ends and centered over the reel is the proper way to suspend the reel.

If the reels of cable are to be stored for long periods of time, it is good practice to change the position of the reel occasionally so that the weight of the layers of cable do not crush the inner layer, due to the tendency of the insulation to cold flow.

Rolling a reel of cable off the end of a truck and letting it fall to the ground may crush the inner layer of cable as well as break the reel drum. Use skids or back the truck against a slope and use the truck as control as the reel comes down the slope.

The outer layer of lags is often held in place by one or more steel bands. Stand clear when the bands are cut as the falling lags will cover a considerable area. More than one man has suffered a broken foot from falling lags.

If the lags are nailed on to the reel, care should be exercised in their removal. Pry them loose. Don't knock them off with a sledge hammer as the fellow on the other side of the reel may be hit with the lag as it is knocked off the reel.

Rubber exposed to the sunlight deteriorates rapidly. If the cable is rubber-insulated, protect it from the sun and heat as much as possible.

INSTRUCTIONS FOR THE INSTALLATION OF MULTI-TURN MAGNETIC DETECTION LOOPS

It is imperative that the legs of Multi-Turn Loops be spaced in accordance with Figure 25-5 in order to insure proper operation of the recording Fluxmeter installations.

Type 115P cable (10-conductor Herald cable) is provided for the legs of the Loop with type 113 cable (3-conductor cable) for the tail. This arrangement makes it necessary to splice the rubber insulated conductors of the type 113 cable to the Vinylite insulated conductors of the type 115P and this taping operation must be carefully handled. Detailed instructions for making the splice are contained in the last section of this article.

The importance of a bottom survey in order to place the Loop intelligently cannot be overemphasized. A Loop should be laid on a favorable bottom so as to obtain the greatest possible operating sensitivity and to avoid operating difficulties. Usually, the available charts are of little value since they were not made for ascertaining whether a site will meet the exacting requirements of the Loop. The use of a shallow depth recording fathometer is recommended in making a bottom survey. Any Magnetic Loop can be balanced only when both of the Loop areas are affected equally by both the horizontal and vertical components of the earth's magnetic field. This condition is exaggerated in a Multi-Turn Loop, the degree of unbalance being multiplied by the number of turns in the Loop. For the best operation, the horizontal projection and the vertical projection of both areas should be equal. In other words, if the inner and center legs of a Loop are in the same horizontal plane and the outer leg is above or below this plane, then, even though the horizontally projected areas may be perfectly equal, the outer area would reflect changes in the earth's field to a greater or lesser extent than the inner area, and the difference in flux linkage would be very difficult to balance out.

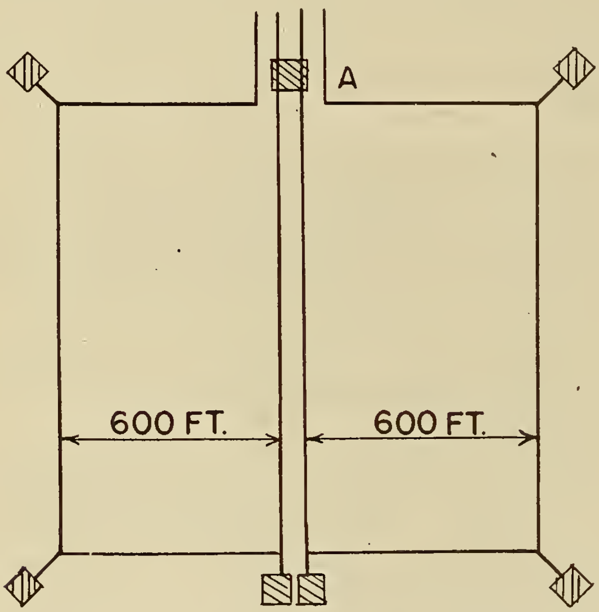


FIGURE 25-5—Proper spacing for the legs of Multiturn Loops.

The vicinity of reefs should be avoided since a sharp rise of a reef may cause sufficient turbulence to move the Loop cables, thus lowering the operating sensitivity of the system.

The Loop system will require four legs: namely, two center legs, an inner leg and an outer leg. Laying of the middle legs requires special consideration in view of maintenance problems that may later develop. Two general conditions are presented:

(1) The case of a channel Loop located in relatively shallow water.

(2) The case of a deep-water Loop, probably located outside of a channel entrance.

Under the conditions of case 1 the Loop is subject to many hazards not present in the outer harbor Loop locations such as emergency anchoring operations and other operations which may result in damage to the Loop. It is possible to lay this Loop with the center legs lashed together with soft iron wire, making splices at each side of the channel. This method is applicable only in places of shallow depths and relatively short length of Loop, for the two cables lashed together will be relatively difficult to handle. Another possibility exists if landmarks are available for course markers such that a small separation of the Loop areas can be accurately made. A small separation in this case is permissible because it is not as probable that the effect of moving magnetic fields due to this small separation of areas will be of sufficient magnitude to affect the operation of the Loop.

Under the conditions of case 2 it is impractical to lay the two center legs with reasonable separation. Therefore, as an example, the cable of the inner area Loop should be laid first, followed by laying the cable of the outer area Loop, with its center leg on top of the inner area Loop center leg. If the equipment is available, it is advisable to splice and load all the cable required to enclose one area, thus leaving only the tail cable splice to be made at sea.

PROCEDURE FOR LAYING

The Loop and tail cable position should be laid out in accordance with the foregoing instructions and buoyed. The use of land reference points as much as possible is highly desirable since buoys are variable in position.

Anchors indicated on the diagram of Figure 25–5 are optional. However, the anchor at "A" is recommended for all installations because it will form a key position from which to reference all operations, and, in addition, will relieve the tail cable of strain in case one of the Loop legs is picked up by a ship's anchor. Two anchors are provided at "B" to permit spacing the center legs if found desirable in shallow water installations. All ends should be well marked to avoid errors in splicing when the tail cable is spliced in.

In shallow waters it may be possible to lay the two center legs of Figure 25–5 either lashed together or separated by a small distance. Both methods have been successful. Since grappling operations at depths of 100 feet or more are difficult, it is questionable whether the separation of the center legs can be justified from a maintenance standpoint. In operating the Loop system, the effect of moving magnetic fields on large area Loops with separation of a hundred feet or more on the center legs will be much greater than on Loops with closely spaced or overlapping center legs. In view of these facts it is suggested that no attempt be made at separation, and that the two legs be laid one on top of the other as nearly as practicable.

Lay the tail cable from the beach to the position of the tail cable splice at the Loop position. Carefully consider the course to be followed in laying the tail cable to avoid emergency anchoring areas, choosing channel boundaries in preference to channel center lines. Cross the channel center line well at sea in preference to a point in the channel where dragging anchors, dredging, and other similar hazards to cable is most vulnerable to damage, its entire length and all splices should be carefully plotted and recorded to assist in possible future repair operations.

SPLICING THE CABLE

The straight splices in both the type 113 and the type 115P cable should be carefully made.

The tail splice can be made on shore with stub cables and straight splices made to the Loop legs at sea, or the tail splice can be made at sea.

The tail splice is a special operation which should be made as follows:

(1) In splicing the four ends of the 115P cable the conductors shall be arranged so that the red lead will be the terminal of the outer leg, the white the middle legs, and the blue the inner leg.

(2) Care must be taken that the conductor ends are spliced so that a continuous 10-turn coil is formed in the manner illustrated for a 2-turn coil in Figure 25–6. The 10-inch conductors on each cable will be the two terminals of the coil. Test with a multimeter before each conductor splice is made to insure proper arrangement. When the splices have been completed, measure the resistance of each coil and record the value for future reference in case of trouble. Check the insulation resistance with a megger. Patch the conductor in the standard manner.

(3) When the jacket is being patched the 10-inch conductors must be brought through the patch, care being taken to see that a good seal is obtained between the jacket patching tape and the conductor insulation on each of these conductors.

(4) Splice the end going to the seaward (outer) leg of the Loop to the red conductor in the type 113 tail cable, the end going to the shoreward (inner) leg of the Loop to the blue conductor, and the two ends

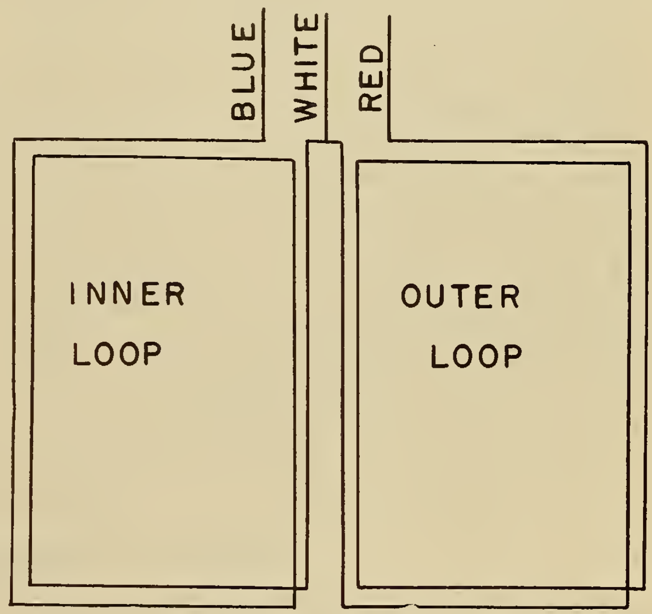


FIGURE 25–6—Connections and form for a two-turn coil.

from the center legs to the white conductor. The conductor splices must be made with married joints rather than sleeves because the wires are not all the same size. Patch the conductor insulation. Particular care must be taken with these patches to obtain a good seal.

(5) Lay the five cables in such a way that three extend in one direction from the splice and two in the other. Cover the splice with five or six layers of friction tape to provide a good bedding for the armor.

(6) Restore the armor and lash the cables together.

A word of caution is here advisable with regard to the use of rubber and Vinylite cements. The solvents used in the cements will attack the tape if not sufficiently dried and will cause deterioration of the entire splice. Allow all cements to dry to a "dry-tacky" condition before taping.

THE TELL-TALE LOOP

Purpose: The Tell-Tale Loop is a fixed underground coil used with the Recording Fluxmeter Equipment to obtain a continuous record of disturbances of the earth's magnetic field. This record is free from perturbations due to cable movements and from vessel signatures, and so constitutes a standard of reference for simultaneous records obtained from Magnetic Detection Loop systems to aid in appraising the significance of unusual variations in the latter. Thus, a comparison of records will show immediately whether or not any unusual variation or signature is due to the earth's field.

Requirements: The output of a Tell-Tale Loop depends upon the number of turns (N) in the coil, the area (A) included by the coil, and the magnitude of the variations in the earth's magnetic field. The effectiveness of the coil or Loop in producing flux linkages (output) may be designated by the product (NA) of its turn multiplied by its area; this NA may be expressed in square-foot-turns (sq. ft. t.) or in square-centimeter-turns (sq. cm. t.). In order to produce satisfactory output for use with the Recording Fluxmeter Equipment, a Tell-Tale Loop should have an area of approximately 50,000 sq. ft. t. or 45,000,000 sq. cm. t. This may be accomplished with a coil of 150 turns 20 feet in diameter (9425 feet of wire). For such a coil,

$$NA = 150 \times 20^2 \times 0.7854 = 47{,}124 \text{ sq. ft. t., or}$$
$$(\times 928.8)$$
$$= 43{,}768{,}771 \text{ sq. cm. t.}$$

Installation: The Tell-Tale Loop should be made of rubber-covered wire No. 14 BWG. or larger buried in a horizontal position 18 inches or more below the surface. The Loop should be located as far as possible from roads or streets, since moving automobiles will produce spurious variations. The distance to the nearest road should be 50 yards or more, and to the nearest electric railway, 1,500 yards or more, unless experiments indicate otherwise. The diameter of the 150-turn coil may be larger than 20 feet and it need not be circular, but its NA in sq. cm. t. should be known.

Calibration: The operating sensitivity of the Recording Fluxmeter Equipment when used with the Tell-Tale Loop is determined for use with the magnetic detection loop system. This sensitivity is expressed in flux linkages, or maxwell-turns, per millimeter deflection of the pen on the recorder chart. However, the magnitude of the variations in the earth's field is usually expressed in gammas. A gamma is 1/100,000 of a gauss, or 1/100,000 of a maxwell per square centimeter, so the sensitivity expressed in gammas is:

$$\frac{\text{Maxwell-turns per Millimeter} \times 100{,}000}{\text{NA of Tell-Tale Loop in sq. cm. t.}} = \text{Gammas per Millimeter.}$$

The magnitude of the variation or signature in gammas is found by multiplying the deflection in millimeters by the sensitivity just obtained.

DUTIES OF LOOP-STATION PERSONNEL

It is imperative that the Loop Station report immediately to the designated authorities all instances of vessels crossing the Loop or Loops. This report should be made at the instant the recorder pen starts the signature, in order to avoid the delay which would be caused by waiting for the vessel to travel the 400 yards necessary to cross the Loop and complete the signature. It is impossible to determine definitely from a signature the direction in which a vessel is crossing a Loop. The direction of travel should be given only when the vessel is visible over the Loop area.

The following information should be written on the recorder chart:

(1) Time signature starts and time chart is restored to slow speed.

(2) Operating sensitivity in maxwell-turns per millimeter during signature.

(3) New operating sensitivity after any change.

(4) New injected-voltage value after any change, with arrow pointing in direction voltage is applied.

(5) Identification by suitable mark whenever the recorder pen is intentionally or inadvertently moved.

(6) Date (once every 24 hours).

(7) Any other pertinent data available from other sources such as name, type, and displacement of vessel, and its course.

The following information should be recorded in the Station log book and Items (4) and (6) to (9) marked with an asterisk should be reported immediately to the designated authorities:

(1) Time signature starts.

(2) Name, type, displacement, and course of vessel, if obtainable from other sources.

(3) Time of making any change in operating sensitivity, and new sensitivity in maxwell-turns per millimeter.

*(4) Time of changing sensitivity because of magnetic or sea conditions to a value less than in table, and time normal conditions are restored.

(5) Time of making any change in injected voltage, new value of voltage, and its direction, left or right.

*(6) Time of closing short-circuiting switch on bench, when necessitated by overloading pulses from magnetic mine sweepers, and time of opening switch to resume normal operations.

*(7) Time of breakdown or operational failure of any Recording Fluxmeter Equipment, cause of failure when determined by maintenance personnel, and time normal operation is restored.

*(8) Time normal operation of installed spared equipment starts after being substituted for operating equipment (not over 30 seconds should be required for the substitution).

*(9) Time of disconnecting equipments from Loops and from power supply because of violent local lightning storms, and time of resuming normal operation.

(10) Magnitude of perturbations at 0000, 0400, 0800, 1200, 1600, and 2000 Local Time, the magnitude being taken as the maximum excursion of the pen (in maxwell turns) in any one continuous direction during the period commencing two hours before and ending two hours after designated time of entry, if excursion was not due to a signature or to normal pen drift or to a sudden power-line transient of too short duration to be mistaken for a signature.

(11) Magnitude of variations in earth's field (in gammas), as measured by Tell-Tale Loop at the times and in the manner just specified for perturbations (Item 10).

(12) State of the sea at the times specified for perturbations (Item 10), using the following scale:

Scale	Description of sea	Height of wave in feet
0	Calm	0 to 1
1	Smooth	1 to 2
2	Slight	2 to 3
3	Moderate	3 to 5
4	Rough	5 to 8
5	Very rough	8 to 12
6	High	12 to 20
7	Very high	20 to 40
8	Precipitous	40 and over

The equipment for each Loop and the spare equipment for each station should be permanently installed and continually energized. The lamp-cord leads from each Model OS Fluxmeter Shunt and from each Model OS–1 Resistance Balance Box should be long enough to reach the "in" terminals of any recorder unit. These leads should be shifted so that a different equipment becomes the installed spare each day, when it should be serviced by drying its activated alumina if necessary, and by thoroughly checking its level and then its operation. Upon completion of this servicing, the equipment should be left operating at slow speed with its "in" terminals short-circuited or connected to a Tell-Tale Loop.

All equipments should, subject to approval of the designated authorities, be disconnected from the Loop or Loops, and from the power line during violent local lightning storms. Lightning striking near the Loops or near the power lines may damage the equipments, so it is deemed wiser to disconnect them during such relatively short periods, rather than to risk having them out of commission several days for repairs.

TACTICAL DISPOSITION OF THE HERALD

From a tactical viewpoint the Herald is the most precise of the underwater sound detection devices, in that with it the operator is able to listen, is able to obtain the bearing on a source of sound by virtue of the supersonic qualities of the system, and, finally, is able to range on that source of sound by transmitting a signal and listening to the returning echo and measuring the elapsed time required for the signal to go to and return from that object.

Actually, this is accomplished automatically by a range indicating device which translates the time element directly into yardage.

The scope of the Herald is wide and the planning officer should never feel constricted by preconceived theories or "musts." The Herald is normally considered to be supplementary to the initial line of detection, being shoreward of the Loops for the purpose of obtaining and maintaining contact with the penetrating craft until the time, as has been pointed out, when the contact can be transferred to the attacking patrol vessels.

However, there is no reason why the Herald cannot be that initial line of detection itself. In many cases where the bottom shelves off rapidly to seaward of a harbor entrance and the Loop installation will be ineffectual because of the great depths, the use of one or more Heralds just off the harbor entrance and ranging out to sea would extend the detection line the presumed range of the Herald, or 2,000 yards seaward.

However, in the initial tactical planning, care must be exerted in selecting the site for planting the Herald to insure that its effectiveness will not be strangled by a rocky projection immediately in front of it, reefs or shoals ringing it or too reverberatory a location in general.

Attention is invited to Figures VII, VIII and IX following, in which the Herald is shown in various tactical

Section III
Section IV
Section V
Section VI
Section VII
Section VIII
Section IX

situations. In Figures VII and IX, it is essentially supplementary to the Loop installation. In Figure VIII it is shown as a secondary line of detection defense, guarding the narrow channel through which the penetrating craft must pass in order to attack the protected harbor area. This theoretical installation is made on the promise that if the enemy craft did, after giving every evidence of its presence in the detection area, elude the patrol vessels, the Herald would give concrete proof that it had passed the patrol line if it obtained contact. If it did not obtain contact, that in itself would constitute proof that the enemy craft was still within the detection area until a departing signature was obtained at the detection line.

Following Figures VI to X inclusive will be found a brief theoretical discussion of the operation of one or more Heralds.

THERMAL SURVEY

Stations having Heralds should investigate the propagational properties of the transmitting medium with a bathythermograph. A bathythermograph can be obtained from your Radio Material Officer.

The maximum range at which objects, submerged or surfaced, can be detected by echo-ranging methods varies widely owing to refraction of the sound beam in the vertical plane. This refraction pattern can be predicted with sufficient accuracy for all practical purposes if bathythermograph readings are taken down to depths of approximately 50 fathoms.

On close examination, the thermal structure of the surface layers of sea water in many areas is surprisingly complex, and since the vertical thermal gradients in the surface layers, in the absence of currents, are largely determined by the winds and the local exchange of heat between the sea and the atmosphere, they can be represented in terms of echo-ranging and detection with about the same degree of reliability as one might expect to forecast weather from a climatological atlas. In some regions such forecasts would be adequate; in others, the day-to-day variations render any sort of average values meaningless.

While refraction can cause the sound beam to have an extremely complex pattern, it may be assumed for general discussion that only four relatively simple situations prevail:

(a) An isothermal surface layer of a depth as great as that in which the Herald is planted.

(b) The Herald planted at a depth where the temperature is still decreasing with depth.

(c) A condition of steep downward refraction.

(d) The Herald planted where the temperature increases with depth.

REFRACTION OF A SUPERSONIC BEAM

Maximum echo ranges are usually limited by the refraction of sound, produced by the variations of temperature, pressure and salinity with depth, temperature being the most important. In an isothermal the sound rays travel in a straight line. Where the temperature decreases with depth, the rays curve downward. Where the temperature increases with depth, the rays curve upward.

In winter, during periods of light winds, surface cooling may for awhile cause the temperature to increase slightly with depth. This apparently unstable condition is most frequently encountered in coastal waters where there is a tendency for salinity to increase with depth, due to the offshore spreading at the surface of relatively fresh waters which have been diluted with land drainage.

Beyond a 100-fathom point, offshore winds frequently carry a thin layer of coastal water out over the more saline oceanic water. Since in winter the coastal water is often considerably colder than the offshore water, sharp positive temperature gradients may be encountered at quite shallow depths, especially along the east coast of the United States. Here the range of the sound beam will depend upon the thickness of the layer of coastal water. The effect on echo-ranging can be most serious when light or moderate winds with an offshore component prevail.

The temperature distribution in the surface layers is influenced by winds and by the exchange of heat between the sea and atmosphere. Turbulence created when the wind produces waves and surface currents will mix the upper layers. The processes of mixing are augmented by convection set up when the surface is cooled by evaporation and radiation. The stronger the wind and the greater the rates of evaporation and cooling, the more complete the mixing, and the thicker the layer of isothermal water.

In tropical and semi-tropical areas, the surface layers of the sea are heated by the sun, and this tends to create temperature gradients in the surface layer. Surface heating, therefore, tends to produce shorter echo ranges. In winter, in latitudes of greater than 30°, the effect is generally just the opposite since the sun heats the surface layers, producing a more even temperature through-

out the depth of the water. This increases the ranges.

Winds of force 4 Beaufort and greater will maintain a well-mixed surface layer even when the water is being warmed. With winds of forces 4–5, echo-ranging conditions are more uniform than with weaker winds, since the mixed layer will usually give a moderate to good range, while other effects will usually prevent the very long ranges sometimes obtained with weak winds. With very strong winds and heavy seas, echo-ranging conditions may become difficult even at very short ranges.

WIND TRANSPORT OF SURFACE WATER

It is often difficult to distinguish between thermal stability (a decrease of temperature with depth) near the surface which has been produced by the local absorption of solar radiation and that which results from a wind which carries a thin layer of warmer surface water into an area where the mixed layer is slightly cooler. In either case the resulting vertical thermal gradients can be equally critical to sound-ranging.

Where the winds are relatively steady in direction and where a land boundary is absent, this effect is at a minimum. It is very serious in latitudes where variable light winds prevail and where the permanent current pattern is complicated. It would not be expected to influence echo-ranging when the winds are strong enough to maintain a sufficiently deep mixed layer.

The transport of surface water by the wind can cause poor echo-ranging conditions in yet another manner. When the wind moves the water offshore, in or near harbor mouths, the mixed layer at the surface will be very shallow, because as fast as it is formed it is carried away. Because of surface heating under such circumstances, thermal stability can be expected even when the winds are quite strong. This is one of several factors which, during summer and in low latitudes during winter, may cause very bad echo-ranging conditions. On the other hand, a local onshore wind may cause an increase in the thickness of the isothermal surface layer and a corresponding improvement in the range.

DIURNAL VARIATIONS IN RANGING CONDITIONS ("AFTERNOON EFFECT")

During the summer season and at latitudes of less than 30° during the winter season, the surface waters tend to be heated during the daylight hours and cooled during the night. With a clear sky and light winds, the temperature of the surface layer may rise during the day, leading to downward bending of the sound beam and a consequent reduction of range. During the night, cooling of the sea surface will produce mixing and will tend to reestablish isothermal conditions and there will be a resultant increase in echo ranges. Minimum ranges will usually exist during the early afternoon hours and maximum ranges will be found during the early morning hours.

When the winds exceed force 4 the effects of diurnal heating will not be so conspicuous and the change in ranges will be less, particularly in open stretches of water.

BOUNDARIES OF CURRENTS

When the permanent currents have north-south components, they can be expected to cause horizontal temperature gradients near the surface. At the edges of such currents, in the absence of strong winds, these may also show up as vertical gradients. Thus the boundaries of currents are regions of variable range. Unfortunately, they do not remain fixed in position, and the width of the band having poor sound-transmitting qualities is rather narrow and therefore difficult to define.

SEASONAL VARIATIONS

Corresponding to the diurnal sequence of heating and cooling there is an annual cycle in heating and cooling. In latitudes between 20° north and 20° south there is little change in the temperature conditions and in ranging conditions throughout the year. In higher latitudes a progressive heating takes place during the spring and summer months. In localities of strong winds the ranging conditions may remain fair during and throughout these seasons.

During the fall months, the loss of heat will first balance and then exceed the incoming radiation, the condition which approaches isothermal characteristics thus tending toward longer ranges. During the winter months, ranging conditions are generally poorer than during the summer.

ECHO RANGING IN SHALLOW WATER

In coastal areas where steady offshore winds prevail, only very short ranges would be possible were it not for the reflection of the sound beam off the bottom. Provided the bottom is sufficiently hard and flat, so that it serves as an efficient reflector, it has the effect of at least doubling the range.

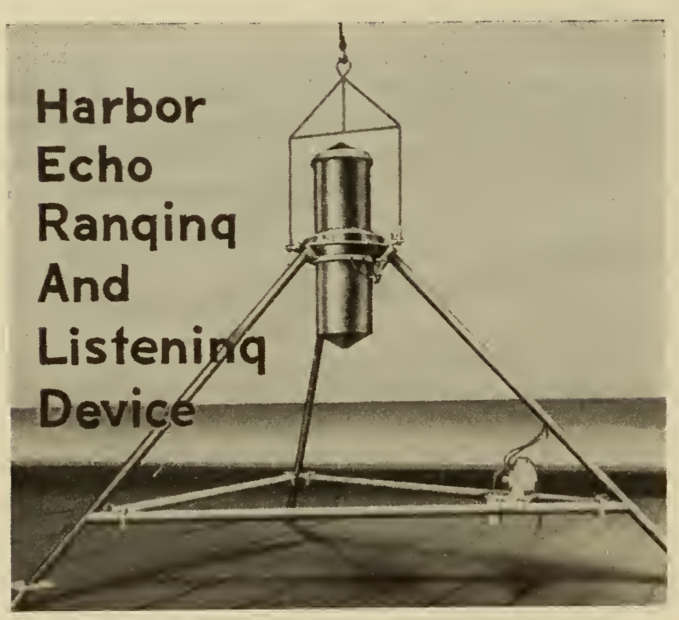
Recent evidence indicates that firm, sandy bottoms usually make good reflectors and in such areas extension of range may be expected when the refraction is downward, whereas over a muddy bottom no extension of range may be expected.

KNOW YOUR HERALD

SOME CONSIDERATIONS ON SUBAQUEOUS REVERBERATIONS

Preamble

In any underwater listening device, sonic or supersonic, the desired signal is always received in the midst of a certain quantity of ambient noise which may be referred to an "ambiency" or background noise. "BG" is more to the point and simpler to remember and will therefore be used.



At times the BG may be loud enough to mask the desired signal entirely. At other times the signal, due to its characteristic, may stand out with clarity even in cases where the BG is actually louder in terms of measured electrical level. To place the desired signal on one side of the scale and balance it against all undesired noises is to create an artificial distinction, but a very necessary one.

A DEFINITION OF REVERBERATION

Although reverberation is present in sea water at all times when there is a source of sound of any nature whatever, for the purposes of this explanation only reverberation as it is encountered in Herald echo-ranging will be discussed. The Herald emits a pure tone or, to all practical purposes, a single frequency; whereas any other sound except the sharp impact of hammer blows are complex in nature, and the ramifications of their action underwater are so diverse and complicated as to be beyond the scope of the present writing.

The whole of the background noise is often loosely referred to as reverberation, but in the interests of accuracy it should be recognized as being composed of two parts, one of which will henceforth be called BG and the other Reverberation. It is necessary to carefully distinguish between the two as the former only is heard when the Herald is used as a listening device; whereas the latter is always present during ranging.

For the purpose of this discussion, reverberation, therefore, is associated only with the sound sent out by the Herald. It starts only at the time when a "ping" is being transmitted, and it dies away gradually and very soon after the termination of the "ping." The intensity of the reverberation is directly proportional to the power and duration of the "ping."

While reverberation in sea water shows some similarity to the well-known reverberation in a "live" room, in many respects it is different. The difference is due to the fact that the region in which the sound travels under the sea is not limited by fixed definite boundaries like the walls of a room. It is true that the surface of the water and the bottom constitute fairly definite boundaries, but in a horizontal direction the sound can keep on traveling in the same direction more or less indefinitely, without being reflected back. However, the water itself is not entirely homogenous, and part of the sound passing through it is scattered in all directions being further scattered by many minute centers of inhomogeneity. In themselves they are too small to give rise to genuine echoes, but they produced reverberation in direct proportion, as has been pointed out, to the intensity and duration of the transmission.

In concluding this definition of reverberation, it may be said that reverberation is a function of the BODY of the water, the SURFACE and the BOTTOM. This will be treated in separate paragraphs below, together with the Statistical Nature of Reverberation.

STATISTICAL NATURE OF REVERBERATION

It might be presumed that the intensity of reverberation is a mathematically smooth function of time.

It is oftentimes implied that a short time after the cessation of the projected sound the intensity of reverberation is great but fades away smoothly and gradually, getting always fainter and fainter as time goes on. Everyone who has listened to echo-ranging knows that such is not the case. The most obvious property of reverberation is its variability. This variability is associated with the phenomenon of interference.

Because sound is transmitted by wave motion, the sound intensity as measured at a particular spot reasonably close to two similar sources does not always have twice the intensity which would be observed if only one source were present. At a particular instant, at a particular place, the sound from two such sources may interfere destructively so that the two sounds annul one another completely. In this case the observed in-

An RCA Herald receiver in operation.

tensity is zero. At the same time and at another place, however, the sounds from the two sources may combine constructively so as to give four times the intensity due to one source alone. These are two extreme cases. At the same instant, at other places near the two similar sources, intensities will be observed ranging all the way from 0 to 4. Just what value of the intensity occurs depends in a critical way on the exact positions of the sources and on the position at which the observation is made.

To observe such interference effects, it is not even necessary to have two actual sources of sound. Any object which reflects or scatters the sound falling upon it becomes itself, in effect, a source of sound. It has been authoritatively stated in explaining doppler effect: "In the application of doppler effect to subaqueous echo-ranging, the submarine or other vessel upon which the Herald is ranging becomes, in effect, the source of sound, as it is the sound reflected from its hull, and the motion of the hull, which gives rise to the doppler effect. The reverberation which immediately follows the transmitted impulse, created by sounds reflected from nearby objects, is of interest only as a base tone with which the returning echo may be compared for doppler effect."

Interference effects, therefore, grow in complexity as the number of sources, real or effective, is increased. Hence, the interference pattern to be expected from the numerous scattering centers which are responsible for reverberation can hardly be a simple one.

But this is not all. If these numerous scattering centers were firmly fixed in position, the interference pattern, though complex, would be constant in time for a given position of the Herald. However, the scattering centers—that is, the bubbles of air, the suspended solid mattter, the turbulent regions, and the regions of temperature variation—are all free to move. The interference pattern will vary from one moment to the next, or, in other words, the irregularities of reverberation will vary widely from one ping to the next and can be described adequately only by statistical methods.

REVERBERATION FROM THE SURFACE

In order to make clear the meaning of reverberation, the discontinuities in the water, such as air bubbles, suspended solid particles, and the like have been assumed to be uniformly distributed through the sea. This, however, is not the case. The main body of sea water, looking at it as a cross section from surface to bottom, is relatively free from bubbles, solid matter and turbulent regions, and, therefore, the main body of the sea scatters a relatively small percentage of the sound. Near the surface, however, there is usually a layer of water, the wind swept (or isothermal) layer possessing considerably stronger scattering power. It may be assumed that this scattering is due mainly to air bubbles, a direct product of the "white caps."

REVERBERATION FROM THE BOTTOM

In shallow water the bottom is the principle contributor to reverberation. If the bottom be flat and hard (firm and shell) little sound will penetrate it, and it will be in essence merely a diffusing surface.

Should the bottom be of gravel, or mud, into which the sound can penetrate, then the mathematical fiction of the bottom being a plane or "plain" surface must be replaced with something analogous to the upper, wind-stirred and bubbly strata, however, of appreciable (depending on the depth of mud), but constant, thickness.

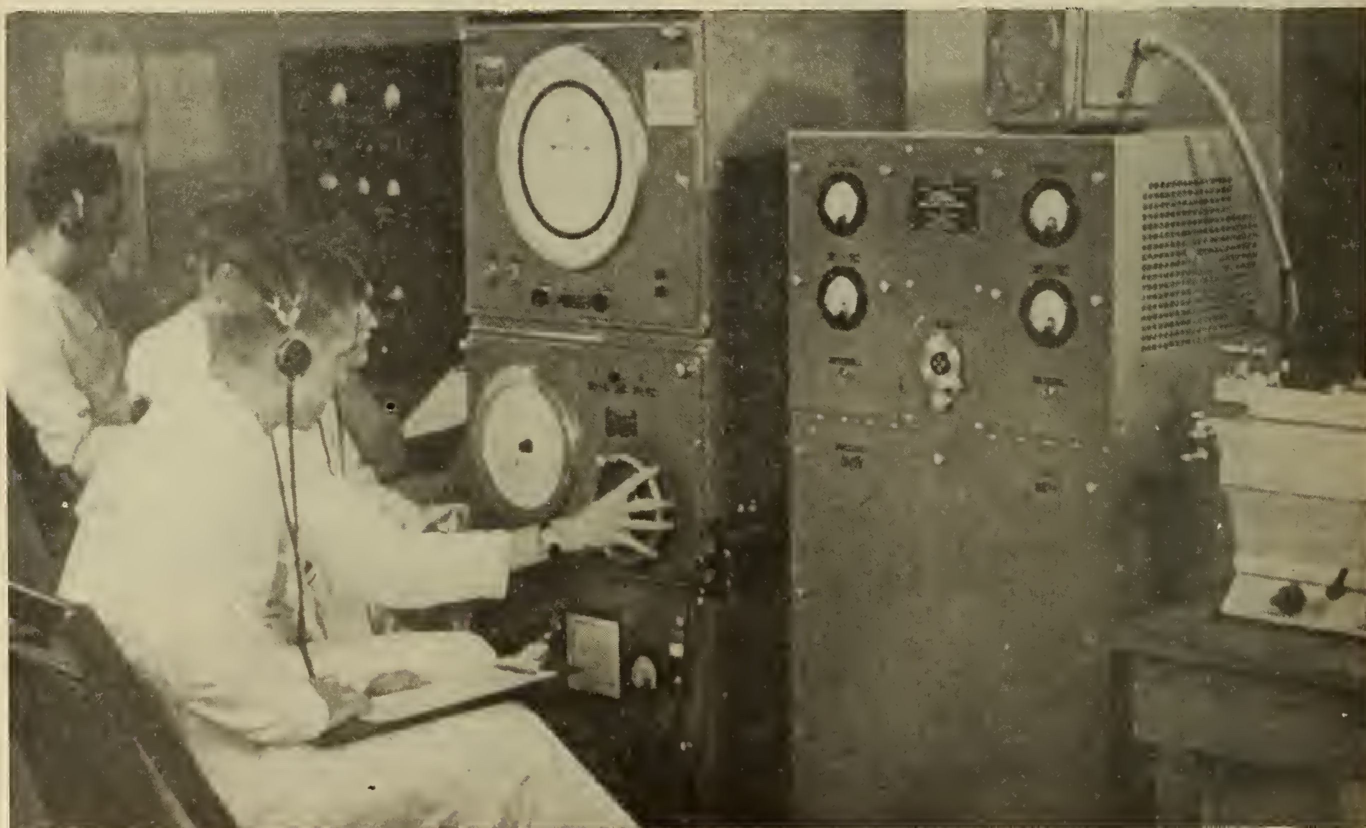
These two constant and idealized conditions, however, are seldom encountered. The actual ocean bottom differs from either an idealized scattering or diffusing layer in view of its having larger features. Most often it is rough, having some parts raised above the general bottom level. These portions project into the path of the sound and reflect an appreciable fraction of the energy back toward the Herald. As a matter of fact, in order that the bottom may reflect sound backward in this way it need not be very irregular. Quite small areas which are within 10° or 20° of the vertical, like the walls of small holes, or the sides of small ripple marks,

are enough to give substantial fixed echoes. This effect will be more prominent when the oceanographic conditions are such as to cause downward refraction of the sound beam.

It is obvious, in passing, that large, fixed echo points are less deleterious to Herald echo-ranging, than are numerous, small scattering centers which perhaps are in violent motion, and are, therefore, to be preferred. The significant reverberation constant will be of a lower order in the former case.

It is perhaps rather difficult to relate any of the foregoing theoretical discussion to actual Herald operation. However, in the need of knowing the contours and characteristics of a harbor it would seem that much of the foregoing could be applied analytically in preparing plans for siting the Herald and Heralds most advantageously, and in forecasting what might be expected by way of day-to-day operation.

An intimate knowledge of tidal action alone, with a plot of tide-rips and strong currents (and their production of scatterers through turbulence) would give the detection officer a lead to some of the reverberation phenomena of his harbor.



Herald shore terminal unit is being tuned by student watchstanders at NTS, Fishers Island, New York.

PLANTING YOUR HERALD FROM A BUOY BOAT

The following explanation shows how herald equipment can be planted using only a minimum amount of equipment usually available at an underwater detection station:

Here are the requirements:

(*a*) One buoy boat.

(*b*) Three net cans or nine gasoline drums.

(*c*) Assorted pieces of line, shackles and wire rope.

(*d*) A beach, preferably sandy, which slants neither too fast nor too slowly, and which is not exposed to heavy seas.

(*e*) Fifteen men.

(*f*) A complete set of herald equipment.

The general idea is to lash a buoy to each of the three legs and push the unit out into the water until it floats. The unit should then be lowered from the buoys until it is suspended from the buoy boat. Next, proceed to the proper location, lower the unit to the bottom, maintaining the control cable ends in the boat. Proceed then to the buoyed ends of the cables leading into shore and make the splices. If any of the new models are available, orientation of the unit on the bottom is not required.

CABLE-CONNECTED HYDROPHONES

The Cable-Connected Hydrophone system was developed to provide a means of transmitting subaqueous ship noises picked up by anchored Hydrophones to shore over cable conductors where they are amplified.

Thorough tests and experiments have indicated that Hydrophones connected to shore should not be spaced more than 1,000 yards apart in a line across the channel to be protected. With this spacing, at least one Hydrophone can usually be depended upon to transmit the sounds produced by a slowly moving submarine even in the presence of a noisy surface vessel.

To determine if conditions are suitable for an installation of this type, a survey should be made in the area where it is proposed to use them. If the bottom is not relatively flat or smooth and if the water background noise is excessive, it may be necessary to locate the Hydrophones at other less strategically desirable locations.

The Hydrophones provided will operate satisfactorily in pressures up to 400 pounds per square inch or at a depth of 925 feet. It must be remembered, however, that there are many difficulties encountered in laying submarine cables at this depth especially for a Cable-Connected Hydrophone system where lateral cables

Pontoon barges are usually used at advanced bases in transporting supplies from ship to shore. They are also very helpful, when supplied with a crane, in planting Herald sea units, as the picture here shows.

are connected every 1,000 yards. It should not be attempted at depths over 400 feet unless experienced personnel and good braking equipment are available.

Briefly stated, the underwater portion of the system is made up of one or more tripod-mounted Hydrophones placed on the bottom of the channel or harbor entrance to be protected and connected to a shore station by armored submarine cable. The shore station equipment consists of a submarine cable terminal box, auto-manual switching unit with rectifier, high fidelity amplifier with rectifier, headphones and necessary interconnecting cables.

GENERAL DESCRIPTION

Tripods.—The tripods are approximately eight feet on a side and eight feet high and are constructed of extra heavy 1½ inch iron pipe. They are designed to hold the Hydrophone in a vertical position with the bottom of the Hydrophone approximately 1½ feet above the base of the tripod. Each foot of the tripod consists of a one-foot cube of concrete weighing approximately 200 pounds.

Hydrophones.—Navy type CBD–51038 Hydrophone used with JR equipment is a long cylindrical device approximately 55 inches long by 2½ inches in diameter, with a ½-inch diameter cable extending from one end. It comprises a long skeleton-like steel cylinder within which are supported eight crystal assemblies at 6-inch intervals. One end of the cylinder is closed by a watertight barrier, through which extend two insulated leads. The remainder of the cylinder is enclosed in a rubber jacket, and the entire unit is filled with castor oil.

A Herald sea unit is coached to the selected location by using ordinary gasoline drums and floats, and, of course, the buoy boat for towing duties. After the unit is on the installation spot, the drums are cut away from the tripod to cause the unit to sink. This is an example of one way a Herald can be installed without the use of any facilities outside the standard harbor detection competent—just a lot of initiative on the part of the personnel.

Each crystal assembly consists of one 45° X-cut Rochelle salt block with electrodes attached. The active edges of each assembly are acoustically shielded from the oil while the active ends are in direct contact with the oil. All blocks are connected in parallel and to the primary of a crystal to line transformer. The transformer is enclosed in the oil compartment and its secondary terminals are connected to the leads extending through the watertight end.

The cable furnished with each Hydrophone contains two steel strain wires and two copper conductors, the four being surrounded by a tinned copper shield. The strain wires are secured to the Hydrophone by means of a clevis and the copper conductors are connected to the two leads that extend through the end of the Hydrophone. The shield is insulated from the assembly to prevent electrical interference due to circulating "ground" currents. The terminal and clevis parts are covered by a rubber cap which fits over and is clamped to the Hydrophone and the cable.

The Hydrophone should be mounted with its axis vertical and be supported by a tripod, clamping the Hydrophone at the two points so stamped on the outside. Because of its directional characteristics, the Hydrophone, when so mounted, will be equally sensitive to sounds arriving from any horizontal direction but will

A Cable-Connected Hydrophone sea unit, with concrete clumps connected to the tripod legs is ready to be loaded into a boat for transfer to its installation site.

discriminate against sounds approaching from the surface or bottom.

SAFETY MEASURES

The following precautions should be observed:

Keep the Hydrophones out of the hot sun or any other place where the temperature will reach 120° F.

Handle with care as rough handling is liable to damage crystal assemblies, puncture rubber jacket or break internal wiring.

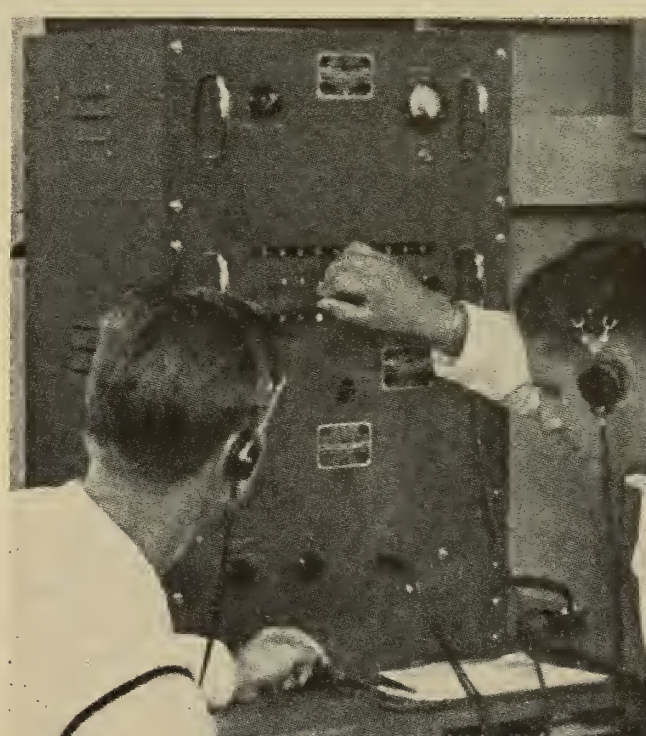
Do not permit oil, acid or any substance that might damage or deteriorate rubber, to come in contact with the jacket.

AUTO-MANUAL SWITCHING UNITS

A figure of twenty Hydrophones has been established as a maximum for one line of Hydrophones, even though not more than seven on one string is recommended because of the listening cycle being too long. An automatic-manual switching unit was designed to permit the automatic scanning of a line of twenty Hydrophones, each one in succession. Automatic operation may be cut out at any time by manually operating one of the keys provided for that purpose. There is one 3-position key for each two Hydrophones with the center position as normal. With all keys in the normal position the switching is performed automatically. If it is desired to listen to one particular Hydrophone for a longer interval of time than permitted by automatic operation or not to wait until its regular turn in the automatic scanning, the key with the number of that Hydrophone above or below it shall be operated in the direction of the number desired. The odd numbers with indication lights for each appear above the keys while even numbers with lights are below. For example, if it is desired to stop automatic switching and connect No. 4 Hydrophone through to the amplifier, the second key from the left should be moved to the down position. If No. 3 Hydrophone is to be connected through manually, operate the second key from the left to the up position. Individually lighted lamps placed above and below the keys indicate the Hydrophone that is connected through to the amplifier on either automatic or manual operation. The switching unit is mounted in a rack that may be placed on a table for convenience of operation.

SITE FOR SHORE STATION

When planning the location of the shore station equipment and the routing of the submarine cable to it, consideration must be given to the proximity of electric power lines or other sources of electrical interference.



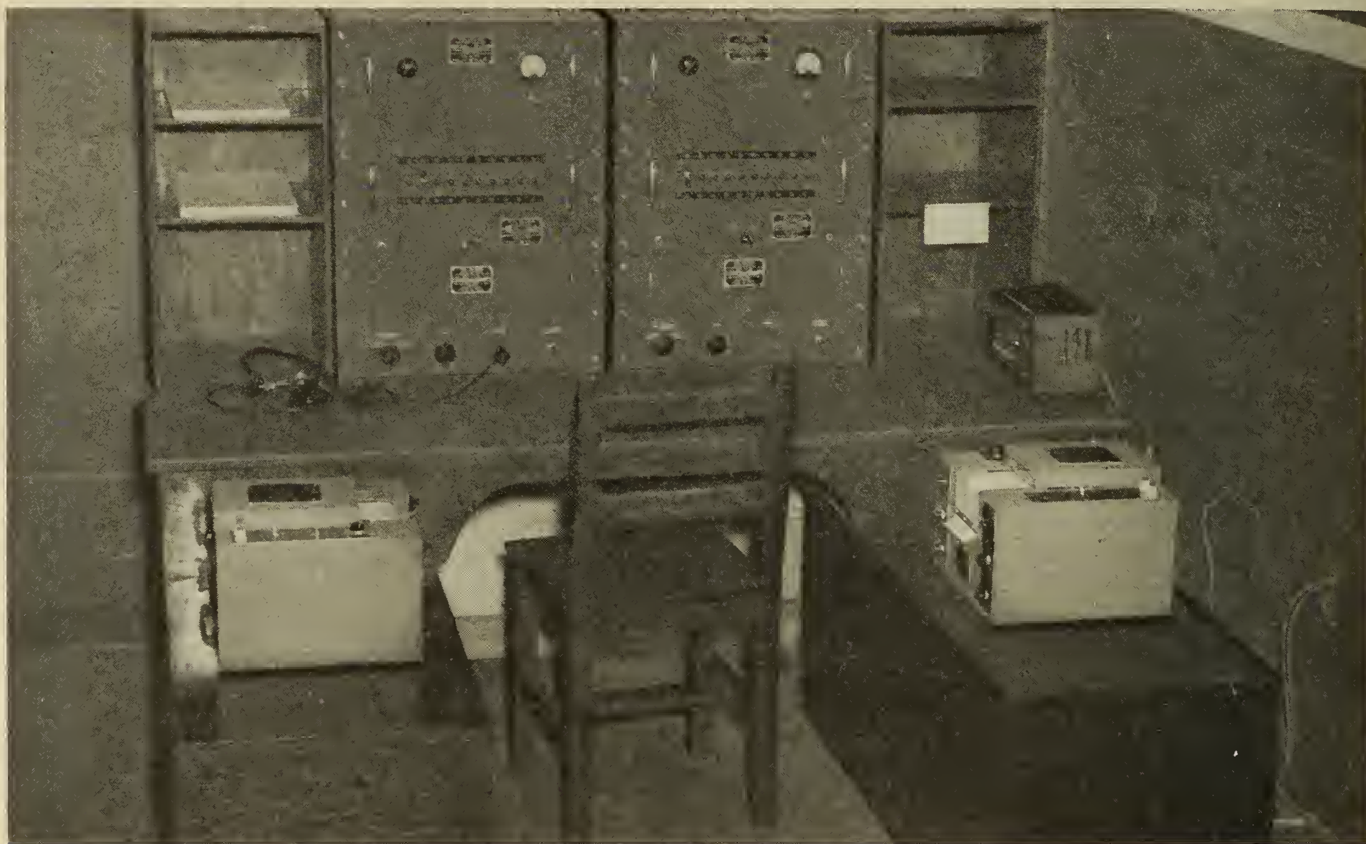
The JR shore terminal Cable-Connected Hydrophone equipment incorporates either manual or automatic "scanning."

RESTRICTED

With the high gain amplifier used with the JR equipment, it is absolutely necessary that there be no pick-up of electrical interference on the cable conductors.

KNOW LOCATION OF HYDROPHONES

It is important that the position of each hydrophone be recorded as it is placed on the bottom of the ocean. This is necessary in order to determine the approximate location of an unidentified vessel when it approaches the line of hydrophones.



It is not generally recommended that one watchstander be charged with the responsibility of two types of units at one time. but it will be noted in the picture above that not only does a watchstander listen on the JR CCH receiver but is also in a position to keep close watch on Magnetic Loop Fluxmeters.

OPERATING INSTRUCTIONS

The primary reason for the installation of Cable Connected Hydrophone equipment at a harbor entrance is to provide a listening system which, operating in conjunction with other harbor detection equipment, will enable the operator to detect enemy craft in case they should try to enter the harbor.

For the equipment to serve its purpose, the utmost vigilance will be required of the operator. In the event of an attempted entrance on the part of an enemy vessel, the chances are that very little sound will be produced by that vessel. The enemy will probably try to drift in, using his engines or motors only occasionally as required to stay on course. To make detection still more difficult, the commanding officer of the enemy vessel will probably wait for reasonable rough weather before attempting to enter the harbor, because the noise of his ship will then be partially masked by the high water-noise level. If the enemy vessel is a submarine, he may attempt to enter while submerged and in the wake of one of our surface vessels, which will further obscure the sound of the submarine's motors.

Bearing this in mind, the operator must listen very attentively and try to interpret every sound that he hears, remembering that the weakest sounds may be the important ones. The headphones should be clamped firmly over both ears, and the amplifier gain adjusted to a comfortable level. In ordinary circumstances, it is recommended that the switching unit be set for automatic operation with a selected listening period on each Hydrophone. When any sound is heard which cannot be identified by the operator, he should then close the key switch for the Hydrophone on which the sound was heard, and continue listening until identification is possible.

The action to be taken when unidentified sounds are heard will be governed by the orders of the local commanding officer.

Local water noise conditions sometimes will make it necessary for the operator to use the amplifier filters for the best signal-to-noise ratio, but whenever conditions permit, the filters should be removed, because without filters a wider band of signal frequencies is heard by the operator and sounds are easier to identify. When filtering is necessary, use only the minimum amount required.

It is desirable to scan the entire line of Hydrophones as often as possible, and yet the operator must listen to each Hydrophone long enough to allow his ear to become adjusted to the particular noise level encountered in order that no sounds will be missed. Listening tests have been made which indicate that a period of 3 or 4 seconds is the optimum listening period, therefore a setting of 3 seconds is recommended for automatic operation. Unusual conditions may dictate the use of a longer, or possibly a shorter, listening period.

The operator should constantly practice identifying the sounds he hears with the equipment. If the detection station is located where the operator can see surface vessels as they cross the Hydrophone line, he should soon learn to identify different types of vessels by their characteristic sounds. Where the line of Hydrophones cannot be seen by the operator, it should be possible for him to check the ship signals he hears with Magnetic Loop signatures and with reports from the Harbor Entrance Control Post and other sources, so that he is always able to identify these signals.

At many installations, the operator may not have the opportunity of hearing a submarine or a motor torpedo boat. If this is the case, he should ask his commanding officer to provide phonograph recordings of these ship signals for training purposes.

INSTALLATION TIME

One of the first things a base commander wants to know is how long it takes to install harbor underwater detection devices at his base. From experience in the field, reports from operating detection officers, and from the two detection schools, a simple table for the installation time of the various detection devices has been made. The times shown in this table are based on the assumption that all material is on hand, that the necessary tools, boats, and barges are available and that all unusual circumstances are barred.

	Days
Temporary detection station	1
Sono-Radio Buoys (7 to 10 units)	3
Magnetic Loop (3 to 4 front miles)	7
Herald (1 unit with 5 miles cable)	7
Hydrophones (7 to 10 units, 6-mile cable)	14
Radar (surface search)	1

For installations at sea the following equipment or its equivalent is necessary:

Sono-Radio-Buoys: Buoy boat.

Magnetic Indicator Loop: Self-propelled quonset barge or AN.

Herald: Self-propelled quonset barge with crawler crane aboard or AN.

Cable-Connected Hydrophones: At least one buoy boat to carry out lateral cables and a self-propelled quonset barge. All barges preferably with two propulsion units.

The following facilities or their equivalents are necesary to handle equipment on the beach:

Sono-Radio-Buoys: Hand truck and small boat dock.

Magnetic Indicator Loop: A crane and heavy truck.

Herald: A crane.

Cable-Connected Hydrophones: A crane.

Surface Search Radar: A light truck.

The amount of transportation in the form of trucks necessary will depend, of course, on the distance necessary to carry various pieces of equipment in putting in shore terminal installations at the detection station and for establishing and maintaining, if necessary, a camp for the detection activity. If the SN surface search radar is furnished with the detection component, installation time is one day. However, if the component is equipped with the new SO7M/N surface search radar, installation time after reaching the selected site for the radar is 15 minutes, since this new radar is completely mobile and is mounted on a truck-drawn trailer.

Many detection installations have been delayed because adequate facilities were not available to handle the detection work and everything else necessary at the base at the same time. It is quite true that in the early days of the war in the Pacific this situation was the rule rather than the exception.

Harbor detection components (B3), when they leave the States, should be completely adequate in both material and personnel to accomplish installation and maintenance provided the B3 arrives at its destination in full strength.

During the war, detection personnel going into the field were among the best trained in the Navy in their own speciality. Since the first feeble attempts at training in 1942, two schools equipped with the last word in detection devices and staffed with the highest quality officer and enlisted personnel were established in the United States. These schools were in full operation for more than two years and turned out hundreds of excellently trained officers and men.

HARBOR DETECTION IN AMPHIBIOUS OPERATIONS

A successful amphibious operation in the Pacific area always provided another strategic stepping stone to Tokyo. In some instances the island provided a much needed airstrip. In other cases the island provided an anchorage of valuable dimensions. In all cases the island provided a beachhead for the amphibious operation and disembarkation area for troops and supporting equipment.

A beachhead in a good harbor area will sometimes pass through several stages such as an emergency anchorage, a limited task force anchorage, a limited cargo ship anchorage, a minor task force anchorage, a small advanced base harbor, a major task force anchorage, and a major advanced base harbor. The following discussion traces the development of the harbor detection installation as the advanced base progressively passes through these various stages:

A beachhead requires very temporary installations to guard ships while landing troops and combat equipment. A line of Sono-Buoys is indicated with the harbor detection station set up aboard ship. Installation of the harbor detection line is governed by local military exigency consequently special team training in rapid installation is necessary. Equipment aboard the vessel from which the Sono-Buoys are planted should be rigged to facilitate rapid handling under combatant conditions. Special training for the crew in personal safety, self-preservation and first aid are necessary in the interests of completing the operation on time.

Establishment of the temporary harbor detection installation will be expedited if all equipment is uncrated, assembled, and tested before the amphibious force reaches the vicinity of the beachhead. Care should be exercised that radio emission during the testing operation does not disclose the presence of the amphibious force to the enemy.

Preparations for the installation of the temporary harbor detection line should be governed by the antipicated degree of permanence, state of the sea, force and direction of the wind, probability of harassing enemy action, and the time at which installation should be started and completed. Advance arrangements should be made for stowage and assembly space, work parties to facilitate preparation of the equipment, and loading the planting vessel. Screening vessels should be detailed to cover the planting operation and to serve as the harbor defense antisubmarine patrol after the detection line is completed.

The future status of the area guarded by Sono-Buoys will usually be known by the time the assault waves have been landed and the beachhead has settled down to routine business of supplying the forces ashore. During this period an anchorage for cargo ships or a limited task force will be required.

This changed status will probably require that the receiving watch for the harbor detection station be moved ashore. When this first becomes apparent, the harbor detection officer should investigate the facilities ashore, select a location for the harbor detection station and a camp site for his men. A work detail selected from men not on watch should be sent ashore to erect tents and set up other camp and station facilities. While this is in progress, the harbor detection officer should make arrangements for direct telephone connections to the temporary Harbor Entrance Control Post and a connection to the base telephone exchange.

He should also arrange for a radio telephone installation at the harbor detection station to use when the telephone lines are out of order or for communications directly with the patrol vessels. The temporary harbor detection station and camp will ordinarily be sheltered under tents erected directly on the ground, and other station and camp facilities will be equally simple. Gasoline-driven generators should be firmly secured to heavy concrete foundations and sheltered under an open-sided shed roof. If two generators are available, they should be set up in locations separated sufficiently to decrease liabililty of both being destroyed by a single bomb hit, and approximately equidistant from the tent used to shelter the detection equipment.

The spare or auxiliary Sono-Buoy receiver should be set up in a well-constructed dugout and power and telephone lines should be brought in to a handy terminal panel. Fox holes should be constructed for all harbor detection personnel and combat gear should be carefully arranged to facilitate its use, particularly in the dark. Several turns of Loop cable should be laid on the ground around the camp at a considerable distance with the ends connected to a fluxmeter recorder to give warning of approaching enemy, especially if the station is of considerable distance from the main camp or in a remote spot. This same installation will be useful at a later date when and if a Magnetic Indicator Loop is added to the detection system.

The harbor detection officer should consult the medical officer relative to taking necessary health precautions and the provisions for first aid. Harbor detection personnel should be drilled every day to perfect their combat training, since the lack of proficiency may cost them their lives. Situations simulating an enemy attack should be created to stimulate teamwork in a crisis. Gasoline, food, and other essential stuff should be stored in several places to prevent simultaneous destruction by the enemy. Electrical wiring should be doubled up between the various terminal points and separated as much as possible. Spare wire should be cut to the right

length, rolled carefully and marked to facilitate rapid replacement of any line in an emergency. Men should be trained to make their way about the station and camp site in the dark, particularly to their battle stations and fox holes. They should be able to find their way to any part of the installation and should know where cover is to be had. The watch should be set ashore using the spare receiver before that aboard ship is secured.

Later echelons will have the additional equipment necessary to carry out the remaining harbor detection plans. This equipment must be uncrated and tested under a shelter before it is installed. Spare parts, tools, test equipment, and certain other elements of harbor detection equipment must be kept out of the weather and carefully handled. Equipment using high voltage should be dried out in a hot locker before it is connected to the lines. Spare batteries for Sono-Radio-Buoys must be stored under a suitable, well ventilated water shed. The size of the storage shelter will be surprisingly large for a complete B3 component. It is well to bear in mind at this stage of construction that the equipment on hand is vital to the successful prosecution of the war and carelessness in exposing it to a short heavy rain may be just as fatal as direct enemy action.

The temporary harbor detection installation that has been described here is designed to provide effective detection facilities ashore in the shortest possible time. This temporary station would normally be used after the amphibious operations were completed but before the base organization is set up. As soon as practicable this temporary station should be improved to create better living conditions and the station should be set up in a wooden frame-supported tent with a wooden deck and screened in. The size of the station structure should be commensurate with the amount of equipment which it will shelter. After the station has been rebuilt to its final form, the men's tents should be made more comfortable by the addition of wooden decks, wooden frames, insect screening, lights, chairs, tables, and lockers.

At the same time a material workshop and small storehouse should be constructed to facilitate storage of new equipment and spare parts and the maintenance of existing apparatus.

The final plans for the harbor detection installation may be sufficiently extensive to require a much larger camp for personnel than was originally constructed. Since the Sono-Buoys provide a reasonably good detection line, it is a good plan to expand the camp facilities and construct the material and maintenance workshop before attempting to make additional sea installations.

The amount of detection equipment called for by the plans will depend upon the extent to which the harbor is to be used as a major task force and major advanced base anchorage. The maximum practicable detection facilities are called for if the harbor is to be used to anchor major units of the fleet or several cargo vessels. The extent to which the temporary harbor detection line can be reinforced will depend upon the depth of water, the shape of the harbor entrance, the force and direction of prevailing winds, magnitude of currents, and prevailing roughness of the sea.

If the water depth does not exceed 20 fathoms it will be practicable to plant Magnetic Indicator Loops. If the harbor is likely to be used for a considerable time, armored cable should be used in preference to the unarmored advanced base cable. The value of the Loop depends directly upon the care and skill exercised in laying the cable. The Harbor detection officer should ascertain that the completed Loop will be as free from perturbations as possible. Personal supervision of the work on cable splicing, anchoring, and cable laying is definitely in order. The instructions on Loop cable laying should be reviewed and followed to the letter. This is one job where exhibition of too much initiative may give poor results, because cable laying instructions were prepared by experts with many years of practical experience. The finished loop should lay on bottom throughout the entire cable length.

The business of getting exactly the right tension on the cable during the laying operation will cause the cable to "roll" down on bottom without piling up. The inner leg of the Loops should be 500 to 1,000 yards outside the eventual line of Sono-Buoys in order that the latter may be used for evaluation of a contact on an incoming vessel. The location of the temporary line of Sono-Buoys will not necessarily be the same as that for the finished system. After the Magnetic Indicator Loops are completed and are in operation, attention should be given to moving the Sono-Buoys to their final locations. If the plans call for use of Cable-Connected Hydrophones in place of Sono-Radio-Buoys, leave the Sono-Buoys at their temporary locations and plant the Hydrophones 500 to 1,000 yards inside of the inner leg of the Loop system. However, if plans call for Heralds, plant them next after the Loops, meanwhile retaining the temporary Sono-Buoy installation. The Heralds will provide a third line of detection and localizing information for evaluation purposes. The final phase of installation for sea units will be the installation of Hydrophones or relocation of the Sono-Buoys. The Hydrophones are to be preferred, because they require no regular service effort and are less susceptible to being run down.

The surface detection radar unit should be set up as early as possible. This unit should be in operation as soon after it arrives as possible to provide information relative to what objects are on the surface in the vicinity of the harbor detection line. It will also prove valuable

in checking the location of the Sono-Buoys and to determine that the Sono-Buoy detection line is intact. The location of the surface detection radar unit should be selected to give complete coverage over the search area, the detection line and the approaches to the harbor. Its location should preferably be such that the PPI scope is in the harbor detection station plotting room to facilitate coordinating Herald and radar plots.

Conversion of the harbor detection station from an amphibious operation to a substantially permanent installation has been described. After the technical aspects of the station have been completed, efforts should be directed to a program of settling down and doing a crack detection job. Peculiarities of the equipment in the chosen location should be followed and discussed with all hands. A program to stimulate further education should be inaugurated, and organized recreation and sports should be made part of the routine daily life at the station. Harbor detection officers should pay particular attention to the welfare of their men and should use every possible means to weld their unit into a happy local organization.

Final stage: Beginning outboard there are, first, three Magnetic Indicator Loops; second, nine Cable-Connected Hydrophones, and last, two Heralds. The Heralds scan the hunting area which is that area between the Cable-Connected Hydrophones and the Heralds. Moored out of the channel and adjacent to the detection station is the patrol vessel which is in radio communication with HECP and the detection station.

MUCH CHANGE DISCOVERED IN NEW SUBMARINE SOUNDS

Exhaustive tests made by an underwater detection station on a new type submarine operating at slow speeds near Hydrophone listening devices revealed that modern submarine sounds have changed considerably from older ones. To the watchstander, the submarine fleet of today is not characterized only by whine and propeller swish sounds, because it has been conclusively proved that at great depths and speeds under two or three knots the whine is almost eliminated and the detection range is not much over 200 yards. This means that if harbor detection personnel are to stay "in the running" on these developments they will have to make several adjustments to their listening technique.

These tests proved that much stress must now be placed upon auxiliary noises as well as the whine and propeller beats in order to guard a harbor against all types of submarines. In order to meet this requirement, harbor detection officers must make available to their watchstanders as much information as possible on new submarine characteristics, must give instructions on the types of sounds that will come from auxiliaries, and must caution operators against using the general conclusion used often in the past—"It's not a submarine unless you hear the whine." By a careful study of new training records, the watchstanders should become thoroughly familiar with such submarine auxiliary sounds as diving planes, blowing tanks, taking on ballast, blowers, pumps, and others, as well as with the characteristic motor sounds of midget and all types of submarines in service today. Such training is of much importance. In view of the fact that our submarine fleet has been quieted, it is best to assume that the enemy has made similar progress with his.

Not all of the devices used in the underwater detection installation are affected by these recent developments. The Magnetic Loop and Herald Echo-ranging gear effectively detect the presence of new submarines as well as old ones. Only in supersonic listening equipment are difficulties encountered. The sounds on which detection of new submarines depend lie in the low audio frequency spectrum (50 to 300 cps.), and detectors designed for supersonic frequencies will not pick up these sounds. Hydrophone equipment, including Sono-Buoys, does not work as efficiently and Herald directional listening methods are much less successful at such low frequencies. The Hydrophone system has an over-all peak response at about 2,000 cycles which drops 11 db. at 500 cycles and 20 db. at 300 cycles. The response from 300 to 50 cycles cannot be accurately determined because of the difference in the manufacture of Hydrophones, but a projection of this curve indicates a further drop of 20 db. at 100 cycles in the case of the Sono-Buoy and at least 7 db. for the Cable-Connected Hydrophones.

In order to make these listening devices effective against the new type submarine, there is one plan to follow, that of listening for auxiliaries. There is no difference in the sound reception of diving planes, slamming of hatches, taking on ballast. It is only that such sounds hold more importance in today's harbor detection plan than in the past.

There is one over-all plan for watchstanders to follow at all times, not only on new submarines but for every type of craft. The plan is explained simply—"Be suspicious of every sound you hear. It may be a contact, and chances should never be taken."

DETECTION ALONE IS NOT ENOUGH

A narrative of a submarine alert at an advanced base in the South Pacific was told by a detection officer present at the time. It is interesting because it indicates the possibility of submarines entering protected harbors even at geographical locations remote from enemy bases. It also brings out the need for careful coordination of harbor defense antisubmarine vessels.

This particular advance base harbor was guarded by a Loop, Sono-Buoys and Herald at the entrance and also had a system of Loops outside of the nets. At the time that the story begins, the sun was bright, the sea was light and visibility was good. The nearest antisubmarine vessel was approximately eight miles to seaward on off-shore patrol. A second antisubmarine vessel (YMS) was in the area outside the nets 12 miles away.

The Magnetic Loop indicated a crossing of approximately 500 flux lines. The Sono-Buoys picked up hydrophone sounds shortly thereafter. A visual scan of the detection area did not disclose anything on the surface. Shortly thereafter the Herald picked up hydrophone sounds and began pinging. The hydrophone sounds stopped as soon as pinging started.

A picket boat, which was standing by at the harbor detection station, was dispatched to the spot indicated by the Herald. Upon arrival, the picket boat stopped and lowered a portable listening unit (hydrophone) and reported hydrophone sounds "so loud that the headset had to be removed from the operator's ears." The contact was reported by radio to the advanced base harbor defense officer and permission to drop depth charges from the picket boat was requested. The reply "negative" was returned, and the picket boat returned to dock and made a verbal report. The YMS was dispatched to the scene but failed to make contact. Antisubmarine patrol of the search area was continued by the YMS with no results.

After a reasonable time, a strong signature was obtained on one of the guard Loops outside of the nets. A picket boat which was standing by the gate vessel proceeded to investigate. There was nothing on the surface in the vicinity of the Loop which had indicated the crossing. This picket boat was not equipped with any sound equipment. The YMS was then recalled to that area and made a search with no positive results.

The nets were closed during the first day and except for passage of ships during subsequent days. At the end of the eight days, the harbor detection station had indications that the submarine was attempting to leave the harbor. Hydrophone sounds were picked up on the Sono-Buoys, and the Magnetic Indicator Loop showed an unidentified crossing. Search of the area outside the Loop did not establish a contact. The search was discontinued on the ninth day.

On the third or fourth day a severe explosion occurred on one of the docks where gasoline, bombs and small arms ammunition was being loaded aboard ship. There is a possibility that this explosion was caused by the submarine. There were many large ships in the harbor which presumably would have been a more logical target for the enemy than was the dock. However, one torpedo or mine would have done more actual damage to our war effort when directed at the dock where three ships were tied up than if expended on a ship at anchor.

There are some interesting points on harbor defense that may be brought out in connection with the above narrative.

Most important from a strategical standpoint is the disposition of the two available antisubmarine vessels. Neither vessel was near enough to the harbor detection line to make effective use of the information obtained by the harbor detection apparatus. Actually, by the time the antisubmarine vessel could reach the last Herald point of contact, the area which must be searched had expanded to 15 square miles. Most of this area was navigable shallow water with a rough coral bottom; certainly not ideal for antisubmarine search purposes.

The picket boat which was on harbor defense had, as a matter of fact, never fixed depth charges. It was generally believed that this boat would have been blown out of the water by the small 300-pound charges carried. There was not enough faith in and understanding of the harbor detection equipment to justify the possible destruction of the picket boat. Besides, the picket boat is not an antisubmarine vessel and is ineffective as such.

There appears to have been too much time lost by deliberation after the contact was reported. Time is extremely important under such circumstances because the area which must be searched increases with the square of the time (twice the time, four times the area). If a suitable antisubmarine vessel could start the attack before Herald contact is lost, no time would be required on the search. It appears that an enemy submarine was not expected, and it was difficult to give credence to the possibility that it was there.

The harbor defense group must operate on the premise that the enemy is near and attack is imminent.

EXPERIENCES AND SUGGESTIONS OF A HARBOR UNDERWATER DETECTION OFFICER

The Harbor Defense Schools provide an officer with a technical understanding of the material with which he has to work and acquaint him with many of the problems he may find in the field. The actual installation and operation of an advance base station is a matter of combining his training with practical common sense.

ORGANIZING THE UNIT

Upon completion of his basic training course, the officer will be assigned to an advance base unit for component training, and there he will get a preview of things to come. The personnel for the unit will be on hand, and organization can be started immediately. He should become familiar with the background of experience, training, and technical knowledge of his men. He should rectify deficiencies in his unit by additional training in seamanship and general practical knowledge. Visits to nearby harbor detection stations will help in this respect.

The commanding officer of the unit will very often require information which the harbor detection officer is specially trained to provide. He may wish information on technical matters relative to Loops, Sono-Buoys, Heralds, and hydrophones, and will probably have an overlay of an expected site to present to the harbor detection officer for study relative to its practicability.

The material for the harbor detection station is usually assembled at a nearby advance base Navy supply depot. The officer should check over all materials with his men and be certain that all necessary equipment is on hand. If he thinks additional equipment is required, he should discuss the matter with his commanding officer and prepare an official request.

Sufficient equipment to cover a six month's period should be secured before leaving the United States. Transportation in a war zone is at best unreliable and the arrival of additional shipments is not to be depended upon. Experience has shown that there is not always an adequate supply of batteries. Voltages should be checked under load conditions before embarkation.

The officer in charge should have a good line on his equipment and personnel before leaving the States.

It is an excellent plan for him to inspect the loading of his equipment aboard ship to insure good stowage and completeness of material. The officer in charge of harbor detection should request to have his unit assigned to the same ship as his equipment. The period of travel from the United States to the advanced base can be utilized in the future training of personnel.

CARE OF EQUIPMENT

The conditions under which the unit may have to disembark are difficult to foretell since stowage facilities on the beach are usually limited to a tarpaulin or tent in an open field. Unloading of harbor detection equipment should be supervised by the officer in charge and his men. The material should be carefully stowed and covered with tarpaulins. In the Pacific rains are frequent and injury to the equipment will result if these precautions are not taken. It is a good plan to have one man inspect the transfer of equipment from the ship to the beach, a second to ride the trucks to the dump, and a third to supervise stowage at the dump. A carefully planned stowage will materially aid in the event the material has to be moved on short notice. Frequent inspections should be made while the equipment is in the storage area.

LAYING INITIAL PLANS

The plans for the harbor detection installation will usually be supplied to the commanding officer of the unit by the area commander. They will be studied by the harbor detection officers for the purpose of making the initial installation as nearly similar as possible. Selection of the site for the station will usually be indefinite because only limited information usually will be available at the time the plans are made. If the site chosen for the station is remote from the main camp, as it frequently happens, the following considerations must be given careful attention:

(*a*) Housing for the men—sufficient cots, mess gear.

(*b*) Sufficient lumber to erect the detection station and a workshop.

(*c*) A power unit with sufficient capacity to carry both the workshop and detection station.

(*d*) Enough tarpaulins to stow gear and provide roofing for detection station and workshop.

(*e*) Carpenter tools for building purposes.

(*f*) Satisfactory operating Sono-Buoy Boat—check winch and hull.

(*g*) Messing and sanitary facilities.

(*h*) Lumber for tent frames and floors, tents and mosquito netting.

ARRIVING AT FINAL DESTINATION

Once the final location of the activity has been decided upon, necessary preparations to proceed may be made at once. Transportation from the stowage area to the eventual site of the station should be carefully supervised to prevent loss or injury to equipment. Begin first by setting up a temporary camp, erecting tents, messing

facilities, sanitary facilities, and foxholes. A harbor detection unit is fortunate if the site chosen for the station is near another camp, because the permanent facilities of this camp may be used by the unit. Under circumstances prevalent at new advanced bases, the Harbor Detection officer should offer to furnish men for security watches, crew's messmen, and general duty details, and thereby promote his relations with other units who can and will help him.

TEMPORARY ESTABLISHMENTS

Once the men have been provided for as to housing and mess facilities, a tent should be set up for a temporary workshop. The location of the workshop should be as close and handy to the docking area of the buoy boat as possible. The next requirement is an area convenient to the workshop for stowage of batteries, spare battery buoys, tailpipes, battery rafts, wire rope, and other similar equipment. Electronic equipment such as transmitters and receivers should be stowed in the workshop. The equipment should next be uncrated, taking care to save all lumber for use as wooden decking in the permanent workshop, tents, work benches, and for general construction purposes. The receiving station should be set up in a tent temporarily, and the generators should be mounted and covered with a light shed roof. Installation of sea units should be started as soon as possible to provide as much immediate detection security as possible.

PERMANENT CONSTRUCTION

After the harbor detection station is operating in temporary quarters, some attention should be given to the construction of more permanent facilities. The station should be set up first and the living facilities improved as time permits. Tents with wooden decks and frames make excellent houses for both equipment and personnel in tropical areas. Tent flaps should be pulled out to form a rain shelter, and mosquito netting should be fitted between the wainscotting and the roof. If the station is located on a hill, it may not be necessary to erect the receiving antenna tower. In this event, the antenna may be perched on the receiving station. Ascertain that the generators give a steady and adequate source of power and that they are separated to reduce the possibility of a bomb putting both out of commission. Set up the standby shore equipment in a foxhole.

PLANTING THE BATTERY RAFT

The procedure usually used was to set all the battery rafts first. Having measured out the necessary amount of wire rope, one end was made fast to the anchor and the anchor hung over the gunwale. The plan in mind was to find the desired location, feed the anchor over first at that point, then brake the cable about 20 feet from its end, take a turn around a bitt and make the bitter end fast to the previously prepared bridle and raft. When this has been done, pull up on anchor wire, free the bight, and swing the battery raft over the side. This method was found easier and more accurate than laying the raft over first, feeding out line and then throwing over the anchor.

LOCATING THE POSITION

If no ship with compensated compass and repeater pelorus is available for locating the position of the buoy, an alternative method is the shooting of two angles, with a sextant in a horizontal plane and using established harbor markings or buoys. The latter method requires measuring the angles to be used on an HO chart, and a sextant which may be readily borrowed from a ship in the area.

PLANTING THE BUOY

Once the battery rafts have been planted and the buoys tested and sealed up, the latter are ready to go to sea. The tie cable should be previously made fast to the battery raft and coiled up and tied so that it can be readily secured to the transmitter. Before going to sea, or while enroute to the raft in question, the tail pipe assembly should be secured, the hydrophone connection made to the transmitter, and the battery connection made to the battery. Upon arriving at the raft, make the buoy boat fast to the raft amidships and head the bow into the swells. Raise the battery out of the boat and lower it into the raft. In using equipment which does not clamp the battery to the raft, use a piece of line and secure the battery to the raft, making sure that the line is free from the breather valve. Connect the tie rope to the transmitter and then lead the battery and battery raft forward and secure on the bow. Connect the battery connection to the transmitter buoy, raise the buoy, and connect the ground plane and spike. Lower the transmitter buoy into the water, open the A.F. gain, leaving the hydrophone in the boat during all these operations.

If radio telephone communication is available, a check should be made to determine if the frequency is correct and if the desired reception is obtained at the listening station.

If voice communication is not available, visual communication possibly could be used and replies made by speaking through the hydrophone. If neither of the two is available, the buoy carrier strength may be checked by using the wavemeter. In either case, speak over the hydrophone for a few minutes to enable the watchstander at the receiving station to check the reception. When the buoy has satisfactorily been planted, check the tie and battery cable and make sure both lines are free. Cast off the bow line holding the battery raft, back off and feed the hydrophone cable over, finally throwing the hydrophone clear. For efficient and safe operation,

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six men should man the buoy boat, with this suggested distribution:

(*a*) Operator for winch 1
(*b*) Operators for guy lines.................................. 2
(*c*) Handling equipment 2
(*d*) Coxswain 1

Where calm seas are anticipated, one of the operators outlined in a, b, or c, can be used as coxswain for the boat, and once the buoy boat has been made fast to the raft, he can assume any of the other duties, abandoning the coxswain watch.

IDENTIFYING BUOYS

Before planting the buoys, it is a good plan to notify the commanding officer, suggesting that he publish a notice to all ships that Sono-Buoy installation is to be effected in the harbor area. General locations should be given and all ships should be warned to keep clear.

REPORTING CONTACTS

Harbor detection stations are frequently located close by Harbor Entrance Control Posts. The latter post controls shipping coming in and out of the harbor, gate vessels for operating net defenses; and, in general, is responsible for maintaining a secure harbor. Any contacts picked up by the harbor detection watchstander are evaluated and reported to the HECP watch officer who takes prompt action. If the ship reported by the harbor detection watch cannot be picked up by a long glass at the visual station, a patrol craft with sound detection equipment is immediately directed to investigate the area in question. If a contact is reported at night, a challenge by blinker is issued in the direction of the contact. If an improper reply or no reply is received, a patrol craft is immediately sent to investigate.

A harbor detection station detects the presence of sea craft, evaluates the information, and then makes a report to an activity which is equipped to undertake offensive action. The HECP maintains liaison with the local coast artillery and may direct their fire when it decides enemy shipping is present.

Out at sea, Sono-Buoys are very difficult to see at any range in excess of 600 yards. Marking the buoy to make it more visible is usually dependent upon the local command. Some may feel that they would prefer an occasional loss of buoys, rather than to advertise the presence of buoys. Others, however, may feel that they should be made more visible. If the latter is the case, pennants 30 by 18 inches can be secured to the antenna. Painting the antenna a light color helps.

LOSING BUOYS

Daily inspections should be made to insure proper location and operation of buoys. Although a buoy is "on the air" it does not necessarily mean it is in its proper location. A further value of daily routine inspections is to check as to whether tie ropes and battery cables are in proper condition, and to check the security of antenna connections.

If a buoy is found to be missing from its location, the amount of drift from its usual position will naturally depend upon wind and tide. A fast boat should be dispatched immediately to locate the buoy. If failure results from this search, arrangements should be made to secure the aid of aircraft in the search. An alert watchstander will observe as to whether or not any ships were heard in the area in which a buoy went "off the air" and decisions can be made accordingly.

WATCHSTANDING FATIGUE

Considerable concentrated study has been made to determine the effects of fatigue on sound watchstanders. This was stimulated by the widespread use of expendable Sono-Buoys in fleet air operations. Results obtained so far indicate that passable standards in sound watchstanding are obtained if the sound watch is limited to one hour. This requires that enough men be at each station to enable the OinC to set up suitable watches.

A man should not stand a sound watch for more than one hour without the intermission of a nonsound watch. This requires a watchstander to guard Sono-Buoys for an hour, shift to Loop, radar, visual, telephone, or some other type of watch before being assigned to guard another sound watch such as Herald, Hydrophones, or Sono-Buoys.

The fatigue study indicates that otherwise reliable men start to hear sounds that do not exist when the sound watch is too long. Indications are that beyond a reasonable time limit of one hour, men lose some of their aural acuity and are less sensitive to strange sounds. Commanding officers should ascertain that suitable sound watches are set at their harbor detection stations.

DUTIES OF WATCHSTANDERS

The harbor detection component performs its function by the maintenance of continuous watches on all shore terminal equipment of the underwater detection devices, radar and communication equipment. The watchstanders are normally rotated at least once an hour from a sound watch to a nonsound watch. On a sound watch, telephone headsets should be worn by the operator because loudspeakers interfere with other listening operations.

When a contact is recorded on one of the detection devices, it is immediately evaluated by the operator and the underwater detection officer. HECP is then notified as to the probable type of contact. The watchstanders will keep the underwater detection officer informed immediately when the contact is made on each of the other detection devices. The Sono-Radio-Buoy or Cable-Connected Hydrophone operator will report the sector in which the target is located. The Herald operator then begins to echo-range that sector until he establishes contact and begins to track the target by giving the range and bearing to the watchstanders on the plotting board and on the communication equipment at least once every minute so that the course of the target can be tracked continuously. The visual and radar watchstanders will determine whether the target is on the surface or submerged. The communication watchstander keeps HECP continually advised on all information obtained by each of the watchstanders on the various detection devices. In case the contact is submerged or unidentified, HECP will order the A/S patrol vessels to search the area in which the Herald and listening devices have contact with the target. From then on the communication watchstander should, with the permission of HECP, report the ranges and bearing of the target directly to the A/S patrol vessels as rapidly as they are given to him by the Herald operator. This enables the A/S patrol vessels to immediately locate the target with their ship-borne echo-ranging gear for early hunter-killing operation.

RELATIONSHIP TO HARBOR DEFENSE UNIT

The harbor underwater detection activity is part of the harbor defense unit and under the command of the harbor defense officer, who normally is on the base commander's staff as assistant operations officer for harbor defense. As such, he can coordinate the efforts of all of the harbor defense components with those of the base defense and other base activities.

The underwater detection component is in very close contact with HECP. It obtains, evaluates and relays information of all contacts obtained on the underwater detection equipment to the HECP watch officer for appropriate action. The underwater detection component also has close relationship with the net and boom detail.

Additional buoy boats may be required after a storm or heavy sea to service the Sono-Radio-Buoys or some of the other sea units of the underwater detection system. Net tenders (AN's) and net-tending pontoon barges are excellent vessels for planting Herald sea units and laying submarine cable. Their services can normally be obtained from the net and boom detail through the harbor defense officer.

The underwater detection component is closely connected with the surface detection radar activity. Radar can provide additional information on surface vessels and low-flying aircraft before they reach the detection line and may be asked to use their radar equipment as an adjunct to the underwater detection equipment to cover certain areas which may be out of range of the radar at the underwater detection station.

Close communication must be also maintained with the A/S harbor patrol vessels in order to furnish them ranges and bearings obtained by the Herald on underwater targets and to furnish the patrol vessels any other needed information to carry out effective hunter-killer tactics.

Harbor underwater detection as an operational activity in the advanced base organization should be thoroughly cognizant of the mission of the base and the duties of each of the administrative officers. In addition, a general acquaintance with the personnel, duties and functions of the service and supply activities is essential for the procurement of material, equipment and information required for the normal operation of harbor underwater detection stations.

DUTIES OF ALL HARBOR UNDERWATER DETECTION PERSONNEL

The duties of the harbor underwater detection personnel are to install, operate, and maintain all the equipment assigned to them. The following is a list of the individual duties normally performed by the personnel attached to the underwater detection activity:

(*a*) The Officer in Charge is responsible for the following:

(1) Discipline, morale, health and training of personnel.

(2) Maintenance of the station.

(3) Liaison with HECP and the other defense activities on the base.

(*b*) The watch officer, while on duty, is responsible for the following:

(1) Line charge of the station.

(2) Operating condition of the equipment.

(3) Alertness and efficiency of the watch.

(4) Availability and forwarding of contacts to HECP.

(5) Keeping of a complete and accurate log.

(*c*) The watchstanders, while standing their watch, must be able to perform the following duties:

(1) Stand an alert and efficient watch on all types of harbor detection equipment.

(2) Make adjustments on the shore terminal units and discern any material failure in the equipment as soon as it occurs.

(3) Know the magnetic conditions, temperature, and state of sea prevailing at the time the watch is assumed and the effect these have on each type of equipment used.

(4) Understand and report on doppler effect and use "search in train" procedure for operating the Herald equipment.

(5) Track through and identify window interference and differentiate the various types of IFF. Be able to track and differentiate both surface and air targets and be able to determine their approximate course and speed.

(6) Use correctly and be versed in communication procedure for all communication methods.

(7) Keep a proper log.

(*d*) The maintenance men should be petty officers of CSoMH and/or SoMH 1/c rates whose duty is to maintain in efficient operating condition all equipment and instruments associated with harbor underwater detection.

(*e*) The boat crew is charged with the installation and maintenance of the Sono-Radio-Buoys and the sea units of some of the other underwater equipment plus the water transportation of supplies and underwater detection personnel:

(*f*) The general detail group normally has the duties of mess cooking, truck driving, and other general detail work at the underwater detection camp area.

SoMH WATCHSTANDER SPECIALIST

World War II saw a great many phenomenal developments in electronics with the resulting demand for technicians and operators who were qualified not only in general watchstanding procedure but also in highly specialized fields. It was in such a field of endeavor that the harbor underwater detection officer or man found himself. He had to be well versed in standard Navy watchstanding procedure, advanced seamanship, sonic and supersonic detection principles, ship identification by listening methods, magnetic detection principles, surface-search radar operation, high-frequency radio maintenance, elementary direct current and alternating current theory, and communication procedure and methods. Rarely indeed did the good seaman-technician combination come along in one man; yet, great ability in these two professions was part of the stock-in-trade of the underwater detection man. In addition to the duties on harbor detection equipment in the station, he had to be able to lay and recover cable from a small boat, service Sono-Radio-Buoys at sea, and perform overseas the many chores that arose during and after the construction of a station. A man had to study and train many long hours and have better than average aural ability to qualify for the Sonarman Harbor (SoMH) rate.

The SoMH was valuable in many lines of work; consequently, many were diverted from harbor detection duties. However, since he was a specialist he could not be replaced properly except by another SoMH. As previously inferred, the SoMH had to be versatile since in a period of six hours on watch he was required to man several entirely different kinds of equipment.

If one watchstander were traced through a six-hour watch at a detection station of normal size, his activities during that period were about as follows:

The first hour was spent on echo-ranging work with a Herald. The Herald operator had to be thoroughly familiar with the location of all fixed bottom obstructions within range of the Herald sea unit. He had to be able to identify the various types of targets such as fish, bottom, rocks, wooden ships, steel ships, and sub-

marines by the distinctive echo each gave on a crystal type sea unit. He had to understand his search-in-train procedure well enough so that all sectors covered by the sea unit were searched at intervals, which were short enough to preclude the possibility of a target slipping through one sector while another was being searched. He had to understand Doppler effect and how it could be used in identifying a moving target from a stationary one as well as assisting in course determination. He had to be able to construct a mental picture of the sector covered by his sea unit and be able to spot immediately anything unusual in that picture. He had to be possessed of enough technical ability to adjust his equipment so that it would give maximum results under the prevailing supersonic conditions as well as spot any material failures or partial failures in the equipment he was operating. He had to maintain constant alertness for one hour while he handled this watch, because the enemy was not considered stupid.

An alert enemy would observe the detection activities at a harbor entrance through his own listening gear in an attempt to discover any weakness or carelessness on the part of the watchstanders. If he noticed that the Herald operator swept too slowly or was not able to quickly identify the target, he would time his attempted entry through the Herald sector to pass through one part while the operator slowly searched another. Also, the enemy may have come into the sector covered by the Herald and then went to the bottom to await a break in the scanning procedure which would give him his chance to slip on by. All in all, a Herald watch was no place for an operator who was not rested and keenly alert, and even for the best in the business it was not advisable to stay on a Herald watch for more than one hour without relief, since the average human ear fatigues rapidly on this kind of work. This fatigue cannot be properly relieved by use of loudspeaker, because the detection efficiency of Herald depends on use of the headset. The loudspeaker also interferes with other listening operations in the station.

The second hour should be spent on a non-sound activity such as a Magnetic Indicator Loop watch, during which time a watchstander uses his eyes and gives his ears a rest. During the Loop watch the operator may spend a part of the hour in assisting in the writing of logs or other activities which do not completely divert his attention from the Loop recorder. He must not leave the immediate vicinity of the recorder. The Loop watchstander should be acquainted with the magnetic conditions prevailing at the time he assumes his watch and should check periodically on the earth's magnetic condition by means of a tell-tale loop connected to a separate recorder and fluxmeter.

Usually, perturbations or "drift" noticed on the instruments connected with the harbor Loops would be checked against the tell-tale Loop recorder to determine whether or not they were being caused by a shift in the earth's magnetic field or some other cause. It must be borne in mind that an extremely slow moving target crossing the Loop would start its signature out so slowly that the recorder needle movement may appear to be "drift" which may be caused by a change in the earth's magnetic field. If this movement is caused by a foreign body over the Loop, however, only the Loop recorder needle will move while the Tell-Tale Loop recorder needle will continue to follow the earth's magnetic pattern. Such evidence on the two recorders should be viewed with great suspicion, since this might indicate something is trying to use evasive tactics in crossing the Loop. Loop operators must follow carefully the daily performance of the equipment to anticipate and evaluate "drift" caused by thermal currents in the Loops and in the station equipment. Wind blowing and sunlight shining on the recorder unit has been known to create difficult problems. The Loop watchstander must familiarize himself with the sea characteristics of each of the Loops he is manning, since one Loop may have more cable movement than another and will show characteristics quite different from any of its fellow Loops. The watchstander must understand the equipment with which he works well enough so that when he makes an adjustment such as increasing or decreasing injected voltage he is sure that he is not masking out a slow signature. It is wise to visually scan that area over the Loops with powerful binoculars at regular intervals for the purpose of constantly checking to see whether or not the Loops are recording the passage of all vessels crossing them. Each watchstander should keep himself advised of the activities of all others on duty in the station so that each knows the instant a contact is made on any of the detection equipment.

The third hour may be spent on a purely sonic watch such as Cable-Connected Hydrophones or Sono-Radio-Buoys. These devices pick up underwater sounds in the sonic frequency band, and a good operator on sonic watch can distinguish one type of submarine from another type. He is able to distinguish one type of ship propulsion from another and under most circumstances can determine the type of ship to which he is listening. These sonic listening devices are very sensitive. Under good water conditions a submarine proceeding at high speed on Diesels has been heard ten miles away. He must have sufficient experience to determine whether sounds heard may be from a noisy ship many miles away or from a quiet ship near at hand. At night when unusually good listening conditions are prevalent, a contact over sonic devices at this range can cause a premature alert unless the watchstander correctly evaluates what he hears. A sonic contact with a high-speed target at a range of 10 miles will be weak and composed

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of propeller sounds only, but at two miles or less a contact with the same target will be composed of both propeller and machinery sounds and will be loud.

Experience is needed to determine whether or not the sounds heard are commensurate with the assumed location of the ship. When the propeller sounds indicate a slowly moving submarine it obviously is not very far distant from the sound detector device, whereas a high speed while even though weak in intensity might emanate from a submarine a considerable distance away. Here again the watchstander must be so familiar with the sound characteristics of his own harbor that he knows them as well as the sounds in a familiar room. He must be able to determine whether an unusual sound is from snapping shrimp, croakers, or some other kind of fish, or is man made. He must be aware of the fact that a submerged submarine proceeding at a speed below that of propeller cavitation will make no propeller noises, but will give out main motor hum or reduction gear noises and machinery sounds such as those made while the diving-plane angle is being changed, ballast pumps are being worked, or tanks are being blown. None of these sounds is very loud and the sound operator must be constantly on the alert for the slightest unusual noise coming in over his listening system. It is dangerous practice to have any one man scanning more than seven Sono-Radio-Buoys or Cable-Connected Hydrophones because he can listen to only one at a time. If he listens to each for a period of 20 seconds it takes more than two minutes to cover the entire line. Both Sono-Radio-Buoys and Cable-Connected Hydrophones are planted 1,000 yards apart so that a frontal distance of around three miles is involved in the above case. A very quiet submarine emits sounds which are usually not detectable at ranges over 500 yards. Therefore, under these circumstances it would be possible for a submarine moving at a speed of about two and one-half knots (or below cavitation speed) to pass through the sound screen at one place while the sound operator is listening to a hydrophone at some other place. For these reasons it is not advisable to listen to any one buoy or Cable-Connected Hydrophone for longer than 10 seconds during normal search procedure. It is highly desirable for a watchstander on sound watch to have five Sono-Buoys or Cable-Connected Hydrophones for which he is responsible. This is usually the standard number per sound watch and as shown above is not just an arbitrary number picked at random.

Here again the watchstander must understand Doppler effect so that he may distinguish between a moving and stationary target and be able to tell whether the moving target is approaching his listening gear or leaving it. Doppler effect on a listening watch is used by comparing the sound pitch of the target on two or more listening stations. If the pitch is higher on one than the other, the target has a component of movement toward the listening unit giving the higher pitch. He must be able to determine the approximate type of vessel to which he is listening; and after having once determined that, he must be able to count propeller revolutions per minute and figure out the approximate speed of the vessel. He must be possessed of enough technical knowledge of both the sea and shore equipment to discern any material failure as soon as it occurs. He must be schooled well enough in the use of filters so that he will use them intelligently to assist him in learning all he wants to know of his target rather than use them promiscuously in a manner which may mask those sounds in which he is especially interested. The sonic watch, like the supersonic watch, is very tiring to the human ear, and it is dangerous practice to leave a man on a sonic watch for a period greater than one hour.

The fourth hour may be spent on a communication watch during which time the watchstander may man telephone and radiotelephone circuits or be required to establish visual contact with the patrol vessel or some other ship in the detection area. He must be versed in communication procedure for all these communication methods. As communications watchstander he has to know enough about his equipment to man it intelligently and to spot any material failures as soon as they occur. He has to keep constantly in mind an over-all tactical picture of the harbor so that unusual circumstances do not catch him off guard.

During the fifth hour the SoMH will ordinarily stand another sound watch on either Cable-Connected Hydrophones or Sono-Radio-Buoys. He has had an hour now during which his ears recover their aural acuteness.

The sixth hour is split into two parts: The first half on plotting duty to familiarize him with targets in the search area; the second half to man the surface search radar. During the first half hour, the watchstander becomes thoroughly familiar with all targets being tracked, all ships within the defense area, and all anticipated arrivals and departures. At the end of this half hour on plotting, the watchstander goes on radar watch equipped with a mental picture of what to expect on the radar scope.

An operator should not be kept on radar watch longer than 30 minutes since eye fatigue reduces efficiency rapidly beyond this time, nor should he be returned to radar watch in less than 30 minutes after being relieved. Before relieving the watchstander on duty, the SoMH must learn of the sectors to be searched, the performance of the equipment at the time of relieving, unusual weather affecting performance, number of patrol boats, position of patrol boats, status of all contacts, unusual contacts or activity in the last watch period, and ascertain when the radar set was last calibrated. He does not relieve until he has watched the scope and is fully in-

formed on everything it shows and until his eyes are satisfactorily adjusted to darkness. After this routine he relieves and takes over the watch. Circumstances permitting, the first things he will do after taking over the watch are to test phones; calibrate and peak equipment, utilizing permanent echoes or any other means available; make sure all permanent echoes, buoys, etc., are marked on the scope and that the scope is properly centered. He then resumes search and reports to the watch officer that the radar is performing satisfactorily and all routine checks and tests have been made. During watch he must report all initial contacts immediately, check for I.F.F., and track as often as is ordered by the watch officer. He must report any unusual activity indicated on the scope, such as window interference, jamming, clouds, squalls, etc. He should track all targets by marking the scope with grease pencil, erasing all old tracks. The relief operator, on relieving, does not take over the watch until he has been fully informed of all the data listed above.

To qualify as a watchstander the radar operator must be able to turn the gear off and on, determine whether set is operating properly at peak performance, operate I.F.F., differentiate the various types of I.F.F., identify and differentiate the various types of window interference and be able to track through it. He must be able to track and differentiate both surface and air targets as well as give the approximate courses and speeds of those targets detected. He must be thoroughly familiar with the area, permanent echoes in his sector, and the positions of underwater detection devices in the harbor entrance and approaches. He must be able to identify different size ships on the scope as well as recognize periscopes, clouds, squalls, etc. He must be able to report targets accurately and talk clearly over the phones. He must not get excited. His attention should not be detracted from the scope. Outside of calibrating and adjusting the set, his eyes must never leave the scope while he is on watch. He must be kept fully informed on all expected contacts and must be able to interpret quickly and accurately what the scope shows. He must be so familiar with his equipment that he can handle operating and tuning controls in the dark. He must have a general technical knowledge of the gear and its main parts together with the principles of operation.

The watchstander, whether he be on radar or underwater detection watch, must be encouraged to call attention to any contact or anything he sees whether or not he is sure of himself. It is far better to err and be on the safe side than to hesitate in reporting a possible contact through timidity or fear of censure. There is no cut and dried formula for picking out good radar operators. Of course, a radar operator must be mentally on his toes but many men who are excellent at other watchstanding jobs make poor radar operators. Some individuals seem to be born with the ability to make excellent and reliable radar watchstanders, but anyone who aspires to this type of duty must be able to concentrate his entire attention on one piece of equipment for 30 unbroken minutes. It requires mental stability, the ability to concentrate, and excellent eyes.

From the foregoing it is apparent that watchstanding duties in a detection station are long and tedious; and although they require little physical exertion, the mental and nervous effort expended is considerable. A six-hour watch has been outlined in this article not because six hours on watch is desirable, but because it is not economically practicable for the majority of detection stations in commission overseas to have enough man-power to schedule four-hour watches. The number of watchstanders assigned to a station is based on four six-hour watches per section. Each section should contain twice as many watchstanders as there are underwater sound circuits to be guarded. Those not guarding underwater sound circuits are normally sufficient in number to perform all other watch duties. Some flexibility in the watch scedule can be obtained by lengthening the watch to eight hours. By this means, one of the four sections can be off duty every day to participate in diversionary activities. Another plan which has been used successfully is to set up three eight-hour watch sections instead of four, absorbing the fourth to increase the number of men in each section. By this means the station watch schedule can be adjusted to include one or more diversionary watches to break up the long watch schedule. These diversionary watches may be devoted profitably to camp routine, recreation or education.

HARBOR DETECTION IN WORLD WAR I

Harking back to harbor underwater detection in World War I, it is interesting to note that "tripod" installations, the forerunner of our present Cable-Connected Hydrophone systems, had been made by the summer of 1918 at Fort Wright (Fishers Island, N. Y.), Nahant (Boston Harbor), New York Harbor, and Fort Storey (Cape Henry), Va.

The "tripod" was constructed of angle iron and on it was mounted three hydrophones and a shore operated selector system. A four-wire cable connected the "tri-

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pod" to shore where was located the selector operating mechanism and suitable amplifiers. Two or more "tripods" were coordinated on a suitable base line and by correct phasing and triangulation the source of sound was "fixed" and plotted. Phenomenal results were obtained in depths up to 400 fathoms and gave good readings on a chaser circling at 5,000 yards.

While installations were made so close to the successful conclusion of the war as to have been of questionable combat value, as in the case of the Cape Henry Loops, certain lessons were learned which were again learned 26 years later in World War II. A report from that period, which might well have had its origin in World War II is quoted:

"The chief function of the ('tripod') system is to locate unseen enemy vessels, but it can be used for surface vessels during fog or rain. It can best be used in conjunction with other means of defense."

To amplify that statement is merely to say that it is valueless unless coordinated with other means of defense.

"The chief limitation is interference from other shipping. One tripod may be temporarily rendered useless by such interference. Even then the other tripod or tripods give valuable information not giving the exact position of a vessel."

The underlying thought behind this very succinct statement is: To know that something is going on is far better than not to know!

"Under good conditions, it (the 'tripod') is chiefly a means for getting other elements of defense into prompt action. Even if the time of a chase or tracking is limited because of interference, it is still possible by rapid work to get information which will put into quick operation submarine chasers, bombing planes, searchlights, and any other means of attack or defense." This statement was still true in World War II.

The Cable-Connected Hydrophone of World War II is a far cry from the "tripod" of 1918. The theory of phasing and triangulation was dropped mainly on the basis that a submarine running at "silent speed" could not be heard with any certainty for more than 0.25 miles. With so short a range, the value of the "tripod" or any purely sonic device was admittedly limited.

On 1 January 1942, the first CNO directive ordering super-sonic ranging devices for harbor use was initiated. It called for procurement of a sufficient number of H. D. A.'s (later named "Heralds") to equip 50 harbors. After due deliberation, the Bureau of Ships decided that an average of two units per harbor would be required and consequently the original letters-of-intent called for 100 units.

The major difficulty at the outset was in finding manufacturers, with available time and material, who were willing to accept the undertaking. Finally four contracts were let for four different models, none of which showed much resemblance to the British H. D. A. Wallace & Tiernan were to produce 10 QBC's (the "sea monster"), and 40 smaller units (QBD) patterned after the N. R. L. model. R. C. A. was to produce 40 units of the model QCP, and Submarine Signal Company 10 units of their QCP–1.

Whereas the British H. D. A. used a fixed frequency quartz crystal projector-receiver, the first two mentioned above used Rochelle Salts type crystals, which had no pronounced natural period and consequently greater frequency flexibility (QB-models can be used for both sonic and supersonic listening and ranging). The latter two, as the designation implies, utilize the rugged magneto-striction type transreceiver which has the one disadvantage of being sharply resonant at a predetermined frequency and therefore responds efficiently only to a very narrow frequency band.

Widely divergent reports have been received from the case of the installation at Palermo where no echoes were ever received, to the case of a South Pacific harbor where the commanding officer was so highly impressed and pleased with the Herald installation that he seemed to think it did everything but fire a 21-inch torpedoe at the enemy. Such reports are far from discouraging.

On the lighter side there is the case of the DD entering a certain harbor which had a new Herald installation. Suddenly realizing that he was being ranged on by a supersonic beam, the commanding officer of the DD ordered battle stations, radical evasive tactics, and departed the harbor at flank speed, throwing depth charges in all directions—a perfectly natural reaction under the circumstances.

EAR vs. EYE

Quite naturally one is often prone to overemphasize the value of sight and, in turn, neglects, to some extent, the incredible wonders of the ear. Twenty-one thousand tons of tanker, with 12,000 horse-power driving her through the water, sets up a disturbance which travels through to the Sono-Radio-Buoy's hydrophone. Next, an amazingly complicated bit of mechanism amplifies the disturbance and ultimately turns it into a radio signal. This is intercepted ashore, where it undergoes further amplification and modification through another amazingly intricate series of instruments, emerging, finally, reconverted into sound. All of which would be to no

avail if it were not for the ears of the operator ever on the alert to deduce certain intelligence from the sounds he hears. It's like the old story of the tree falling in the forest not making any noise unless someone were there to hear it!

When one considers that the frequency range (in many cases) of the human ear is from 16 to 20,000 cycles, or more than 10 octaves, while the frequency range of the eye is less than one octave, one can appreciate the relative value of the ear. Furthermore, the ear possesses more analyzing power than the eye, being able to distinguish between as little as a quarter tone change, while the eye cannot analyze color at all or distinguish between two like color sensations made up of different components.

It is pretty safe to assume that the eye evolved in the primitive animal before the ear, as photo-sensitivity is a more primitive mechanism than audio-sensitivity, and is incapable of long periods of concentration of vigil. For instance, the case of the cat apparently asleep, which will become alert at the slightest noise, and subsequently investigate by sight for a brief period. In the meantime the ear has been constantly alert and has not become unduly fatigued.

The ear is capable of coping with an extremely wide range of volume. The range between the sound of a pin dropping, which the ear can detect if the ambient noise levels are not too high, and the sharp crack of a 5-inch rifle is incredibly wide. In comparison, the eye, which cannot see at all unless there is considerable volume of light, and which comes very close to the edge of pain if the light is too bright, is definitely limited in scope.

The ear can assimilate and appreciate the complexities of all the sounds and volume variations produced by a 100-piece symphony orchestra; frequencies from 16 to 20,000 cycles per second; a volume range of 70 or more decibles. The eye, under similar conditions, would become utterly confused and exhausted. The ear responds instantly to any stimuli, and subsides instantly as well. The eye responds rapidly to stimuli, but tends to hang on for an appreciable part of a second; a phenomenon known as "retention of vision." If the ear were afflicted with the same defect, how limited would be its scope? The ear can hear at night as well as in the daytime. As a matter fact, it would be difficult to set up a condition under which the ear couldn't operate. With the eye it is necessary to resort to such devices as "peripheral vision" in order to see under conditions of limited light.

It is not to be assumed that the ear, or rather the act of hearing, does not ultimately lead to auditory fatigue. However, it is assumed that the fatigue does not take place within the ear structure itself but rather within some remote part of the central nervous system. Auditory fatigue will occur more readily in cases where the source is steady, rather than a complex, tone. By this token, Herald operators should be expected to fatigue more quickly than Sono-Radio-Buoy or Hydrophone watchstanders. Contributing to the fatigue, of course, is the monotony of the same tone returning constantly, as in the case of the Herald, whereas the sounds heard on Hydrophones are definitely of a complex nature and therefore more interesting.

For instance, the more complex the timber of a musical instrument, the more readily does it seem to stand out from the various accompanying sounds. The strange "saw-toothed" quality of an oboe or bassoon is much more perceptible than the tone of a flute. Pure tones, then, such as are employed in Herald transmissions, are the most difficult stimuli to perceive efficiently. The ear's sensitivity to slight changes in the pitch, intensity or duration of pure tones is known to be poorer than its sensitivity to complex tones. Among many lower animal species no response at all can be elicited to pure tones, whereas the animal responds at once to complex noises emitted by its own species or by other species on which it preys. When Doppler effect is present in Herald ranging, some slight complexity of tone is derived and therefore becomes very noticeable to operators who might be considered "tone deaf" in other respects. Of course experiments have been made in the direction of producing complex ranging tones, the so-called "sweep modulator" being one of them.

All of which is in the nature of a contribution to "The Ear is a Wonderful Thing" department. In conclusion, as a last faint cheer to the efficacy of the ear, one is reminded of the lighthouse keeper who had tended the light on a certain small island for over 18 years. On the island there was also a small Naval establishment, not so small as to preclude the firing of the sunrise gun. For 18 long years the lighthouse keeper had slept through the firing of the sunrise gun, until one morning, the gun misfired: failed to go off. The lighthouse keeper jumped out of bed and cried out: "My God! What was that????"

BIBLIOGRAPHY OF BUSHIPS PUBLICATIONS ON HARBOR UNDERWATER DETECTION MATERIAL

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Publication (Short Title)	*Title*	*Description of contents*
NavShips 78A–143B.	Instructions for the Installation & Maintenance of Submarine cables & Sea Units for Harbor Detection Equipment.	Cable design & specifications; laying and weighing of cables; cable splicing; testing and fault location; laying and weighing of sea units.
NavShips 900,024.1.	Harbor Detection Bulletin.	Information supplementary to that contained in existing H.D. literature.
NavShips 900,025.	Sonar Bulletin.	Section 25 is a looseleaf continuation of the Harbor Detection Bulletin.
No NavShips No. (Contract NXss 33092).	Cable Detecting Equipment Model OBB.	General Description—Installation, Operation and Maintenance.
Ships 275.	Catalog of Naval Radio Equipment.	The Harbor Detection Section of this catalog contains fundamental technical data, photographs, etc.

II. *Harbor Echo Ranging and Listening Devices (Heralds)*

NavShips 900,370A–1B.	I.B. for Model QBD Herald.	General description, installation, operation and maintenance of QBD Herald.
NavShips 900,369–1B.	I.B. for Model QBH Herald.	General description, installation, operation and maintenance of QBH Herald.
NavShips 900,230–1B.	I.B. for Model QFJ Herald Teacher equipment.	General description, installation, operation and maintenance of QFJ equipment.
NavShips 900,218–1B.	I.B. for Model QFF Listening Teacher Equipment.	General description, installation, operation and maintenance of QFF equipment.
NavShips 900,070.	Herald Ranges.	General description, on the way in which the ocean influences Herald operation.

III. *Recording Fluxmeter Equipments*

No NavShips Number (Contract NOs 84397).	I.B. for Model OS and OS–1 Fluxmeter equipments.	Part 1—General description, installation and maintenance. Part 2—the loop system, loop maintenance, loop station requirements, interpretation of signatures, tell-tale loop.
No NavShips Number (Contract NOs 95853) and (Contract NOs 20422).	I.B. for Model OS–2 and OS–3 Fluxmeter equipments.	General description, installation, operation, and maintenance; loop system and station.
No NavShips Number.	I.B. for CLU S3212 or CAOR 53212 Discriminator Unit.	General description, installation, operation and maintenance of discriminator.

IV. *Cable Connected Hydrophone System*

NavShips 900,245–1B.	I.B. for Model JR–1 Sound Receiving Equipment.	General description, installation, operation and maintenance.
NavShips 900,209–1B.	I.B. for Assembly of Tripod Junction Boxes, Tripods & Hydrophones for JR Equipments.	Assembly instructions for the C.C.H. Sea Unit.
NavShips 900,488–1B.	I.B. for Relay Terminal Box CML 62154.	General description, installation and maintenance instructions for relay terminal box used in C.C.H. installations employing 109 cable only and up to six sea units.

V. *Sono Radio Buoys*

Publication (Short Title)	*Title*	*Description of contents*
NavShips 900,332–1B.	I.B. for Model JM-1 and JM-3 Sono Radio Buoy Transmitting Equipment.	Description, installation, operation and maintenance.
NavShips 900,011–1B.	I.B. for Model JM-4 S.R.B. Transmitting Equipment.	Description, installation, operation and maintenance.
NavShips 900,225–1B.	I.B. for Model RBF-3 S.R.B. Receiving Equipment.	Description, installation, operation and maintenance.

VI. *UEP System*

NavShips 900,074.	I & M of Submarine Cable for UEP System of Harbor Detection.	Description and theory of UEP System; Cable splicing, installation and maintenance of H.D. UEP offshore plant.
NavShips 900,562A.	I.B. for Model OBO Recording Microvoltmeter.	Description, installation and adjustment; Theory of operation; maintenance.
NavShips 900,084.	I & M of submarine cable for UEP Net Gate Detection Unit.	Description, Theory, Installation, maintenance and cable splicing of Net Gate UEP System.
NavShips 900,204.	I.B. for Model OCF Recording Microvoltmeter.	Description, installation and adjustment, theory of operation, maintenance.

VII. *Harbor Detection Radar*

Ships 214.	I.B. for Model SO-7M Radar.	Description, installation, operation and maintenance.

Section III

HARBOR ENTRANCE CONTROL POST

Section III—HARBOR ENTRANCE CONTROL POST

FOREWORD

Regardless of the number of destroyers, cruisers or battleships that struck at the enemy during the war, invariably each of the ships was attached to a squadron or task force, meaning that each ship had a flagship to which it had to report and from where it would receive instructions for further operations. A flagship to a task force is the headquarters, the nerve center, the information center, the place where action originates.

Just as task forces and fleets have to depend upon a control center for all their orders and directives, so does the harbor defense unit stationed on shore and controlling the defenses of a harbor. There are many units attached to the harbor defense unit, just as there are many units attached to a fleet or task force. Because of this tremendous volume of responsibility, the harbor defense unit must depend upon a "flagship" to get its work done and get it done thoroughly.

Harbor Entrance Control Post functions in the capacity of the "flagship" for harbor defenses. Without the services of an HECP, each of the harbor defense activities would be functioning as a "lone wolf." There would be no coordination of efforts in defense. There would be no such thing as an adequate defense in protecting the ships and shores inside the harbor's entrance.

Regardless of the activity one singles out for study in the harbor defense unit, it will be dependent upon another component to have its job done completely. Underwater detection and radar must rely upon the offensive tactics of patrol craft when they receive suspicious contacts, just as patrol craft must depend to a large extent upon information from underwater detection and radar if they are to get to the scene of enemy underwater or surfaced contact within a period of a few minutes. The net and boom component must depend upon another activity to furnish information of expected arrivals and departures of ships and convoys so that the net gate can be controlled accordingly. In other words, each harbor defense component is designed to perform a particular job in defending the harbor. When that job is done, another component takes the responsibility until a complete mission is accomplished.

The one activity in harbor defenses which brings together the efforts of all components is the Harbor Entrance Control Post. Harbor detection and radar report their contacts to HECP where the information is evaluated and transmitted to patrol craft. These reports continue to flow through the HECP center, giving all information that would be of value to the searching patrols. At the same time, by the contact being suspicious, the net gate receives an order from HECP to close the gate to all traffic. A constant flow of information goes to and from HECP throughout any period of suspicious contacts, each component adding its part to the over-all picture and HECP using all of this information for one concentrated attempt to rid the area of any hostile craft in the precious minutes after a contact is received and before damage is inflicted upon friendly shipping. The "flagship" is doing its job calmly, quickly and expertly during this time. It is directing, controlling and managing all harbor defenses.

Quite often assigned Naval personnel think of HECP only as a Naval activity. According to a joint agreement by the War and Navy Departments a short time before the United States entered World War II, HECP is designed to be a joint operation with both the Army and Navy furnishing separate defense components designed for specific purposes. In establishing this joint defense, both an Army and Navy watch officer was assigned to HECP assigned throughout the 24-hour watch and each being delegated certain responsibilities. The system worked very efficiently. Yet, when a ship did get through it was without a doubt a friendly one and the harbor was at no time under a threat of enemy attack.

To try to present many articles on the Harbor Entrance Control Post portion of this manual without repetition would be utterly impossible. There is just one way for an HECP to function, according to Naval and Army standards, and any attempt to present a different working plan would be useless.

The major portion of the HECP section is devoted to a report from the HECP at the Port of Boston, a joint Army-Navy command and controller of one of the largest and most important Allied ports throughout the war. This report tells the complete story.

Boston's HECP came as close to being an "ideal" as was found throughout the war. It followed the HECP plan, and its organization was wide, thorough and exact enough to deal with all problems. The Chief of Naval Operations does not hesitate in saying to all assigned HECP personnel to "lay out your plan accordingly."

All personnel assigned to HECP duty should know in detail the plan for their own base. Then, too, all personnel assigned to any of the other harbor defense components should have a good knowledge of the job which HECP is required to do. Only through such an

understanding on the part of all can a harbor defense unit control the harbor's entrance, keep the enemy out, and, ultimately, keep the ships and shores inside the harbor safe from enemy attack.

The procedure of all HECP's will not be alike, because the topographical conditions and importance of harbors will vary. Many incidental but still very important plans will be outlined. But the success or failure of a complete defense plan will hinge on one simple formula—all Harbor defense activities reporting to HECP and, in turn, HECP, always the flagship, directing the action which may develop.

HARBOR ENTRANCE CONTROL POST

The mission of the HECP is to coordinate and control both the action of the elements of harbor defense and the movements of vessels in the harbor approaches in the preservation of the security of the harbor.

HECP is a joint Army and Navy command post and a communication center. It receives information from all available sources, evaluates this information and decides on appropriate offensive and defensive action. The joint Army and Navy watch at HECP receives information from expert detection and observation stations as transmitted by radio, visual signal and wire. The HECP watch is trained to interpret this information and to order immediate defensive action.

In the performance of its mission, the functions of HECP are as follows:

(*a*) To challenge all ships approaching the harbor entrance and to prevent the entry of any unidentified vessel on the assumption that it may be enemy.

(*b*) To control the movement of vessels in the harbor entrance in the interests of mutual safety.

(*c*) To receive from the port director up-to-date information on anticipated arrivals and departures for reference in establishing identity of ships and in anticipating traffic control problems.

(*d*) To receive from the harbor detection station information concerning indications of the presence of vessels in the detection area for evaluation to determine their character and identity.

(*e*) To receive from the surface detection radar station information concerning indications of the presence of surface vessels in the approaches of the harbor.

(*f*) To pass to patrol vessels all pertinent information which they will require for close investigation of suspicious circumstances.

(*g*) To direct patrol vessels to investigate any suspicious circumstances and take offensive action if appropriate.

(*h*) To control traffic in the harbor and its approaches during an attack.

(*i*) To order the arming of defensive minefields planted in the harbor entrance.

(*j*) To order the closing of net gates and insure the observance of an adequate net patrol policy.

(*k*) To pass to the base operations office information concerning suspicious circumstances and to recommend the use of hunter-killer tactics, smoke, minesweepers, and fleet units in the preservation of a secure harbor and safe approaches.

(*l*) To order the examination battery to fire a round across the bow or to fire for effect on any suspicious vessel or any vessel held in suspicion by her actions or failure to identify herself.

(*m*) To recommend that coastal batteries open fire on vessels held to be enemy by her actions or inability to identify herself.

(*n*) To request that searchlight batteries flood areas suspected of containing unidentified vessels.

The advanced base operations officer may be considered in general charge of all Naval elements of base defense with the harbor defense officer directly responsible for the organization, training and operation of the

This Harbor Entrance Control Post at Fort Story, Cape Henry, Virginia, is in a highly exposed coastal position and is protected by a special seawall to guard against the oftentimes rough Atlantic waters. The building houses all needed facilities for operation, and from an underground post both the Army and naval watchofficers control the traffic by use of radar, radio reports from patrol craft, a signal tower above the dugout, and the signal bridge.

harbor defense group. The operations office is the liaison medium between various elements of the base and HECP. When HECP requires support of offensive or defensive elements which are not directly under the advanced base commander, such as SOPA, coast artillery or aircraft, the base operations officer makes the arrangements. When HECP requires support of minesweepers to clear the channel or searchlights to flood an area, up-to-date information on ship arrivals and departures from the port director or reports from remote radar and coast watcher stations, these are obtained through the base operations office.

HECP should be located near the approach of the harbor, with unobstructed visibility of the seaward approach and of the harbor entrances. Temporary difficulties of supply and transportation should not be allowed to interfere with the selection of a suitable site especially if facilities can also be provided for basing other units with the harbor defense unit, thereby establishing a community for military strength and morale. Facilities should be provided for adequate light and power under all conditions and should include stand-by emergency units. Dispersal of essential facilities should govern the plans for the camp site, and provisions should be made for uninterrupted operation while under fire and during bombing raids. To attain this end, small portable directive signal searchlights and radio equipment should be established in dugouts.

HECP is equipped with navigational instruments, visual signaling equipment, radio-telephone equipment, housing and construction materials, furniture and transportation equipment. Details may be found in the "Advanced Base Initial Outfitting Lists" and the "Catalogue of Advanced Base Functional Components".

MANUAL for CONTROL OF PORT OF BOSTON

HARBOR ENTRANCE CONTROL POST FORT DAWES, WINTHROP, MASS.

Procedure for Examination and Entry into Port of Boston in Time of War. (Paragraphs are headed and numbered to correspand with NDP–1A)

Harbor Entrance Control Post (H.E.C.P.)

1. Boston Harbor Entrance Control Post Signal Station is located on top of the high hill on Deer Island and is distinguished by a 75′ mast with cross arm. The control post is conveniently located with direct communication to the signal station and to an auxiliary signal station on Georges Island and with command telephone lines running to District Headquarters (Navy), District Coast Guard and Harbor Defense Headquarters (Army). Administrative telephone lines connect with Navy Section Base, Fort Banks and Boston Navy Yard. Communications are maintained in accordance with Annex C. This HECP is a joint Army and Navy command post whose mission is to collect and disseminate information of activities in the local defensive sea area; to control unescorted merchant shipping in the defensive coastal area; and to take prompt and decisive action to operate the elements of the harbor defense in order to deny enemy action within the defensive coastal area. An Army and a Navy officer are continuously on watch at this post.

2. The Army and Navy officers on duty in this HECP are empowered to take action in order to carry out its mission. Their duties are detailed in the Army HECP Standing Operating Procedure, Annex A, and the Navy HECP Organization Book, Annex B, and "Instructions for Controlling Traffic," Annex C.

Traffic Control Procedure

3, 4, 5, 6, 7. General Directives of NDP–1A are adhered to. Details are given in Annex C.

Warship Procedure

8. General directive of NDP–1A is followed by HECP in so far as conformation by other elements permits. Minor warships are treated the same as major warships in Port of Boston except for having a different reply to challenge.

Notification of Arrival

9, 10, 11, 12, 13, 14, 15. Specific directives of NDP–1A for "preparatory" and "amending" messages apply to ships concerned, not to HECP.

16. "Preparatory" and "amending" messages are not received at HECP. Information to the Captain of the Port is given by Naval District Headquarters, not by HECP. For reasons of security HECP does not notify the Examination Vessel or patrols outside the entrance. Otherwise the provisions of this paragraph of NDP–1A are carried out as follows:

(*a*) Surface Controller, Northern Group ESF, notifies HECP.

(*b*) Ass't. Captain of Navy Yard phones a summary of movements known to him at 1600 daily.

(*c*) Other offices, such as Fleet Administrative Office, Port Director, HECP at Sandwich, British Liaison Officer, British Routing Officer, CNLDF, ComBosec, Navy Fuel Officer, DOO, DIO and Army Intelligence, may provide some advance information.

(*d*) All advance information is posted on daily sheets of expected movements and corrections made thereto as amending information is received with final verification by Surface Controller.

(*e*) Berthing and any special instructions for expected warships are entered on Expected Movement Sheet. If no such information has been received prior to identification of an approaching warship, the watch officer then phones Ass't. Captain of the Yard (and Surface Controller of ComBosec if necessary) for instructions. Because of crowded conditions at Navy Yards, berthing instructions received twelve hours or more prior to identification of an approaching warship are verified by telephone to Asst. Captain of Yard.

(*f*) Quarantine requirements are determined by (1) presence of quarantinable disease, (2) last port of clearance and subsequent ports of call, (3) whether a commissioned medical officer is aboard. Whenever a vessel is reported as coming from a foreign port, the watch officer must investigate quarantine requirements and make arrangements for same.

Procedure for Identification of Major Warships

17. Examination Vessel challenges all warships approaching from sea, using shore to ship challenge, and reports their approach to HECP by coded message stating only number and class of warship entering. HECP challenges all approaching warships as soon as sighted.

18, 19, 20. HECP challenges by signalling "INT" by directive flashing light. It is the duty of the watch officer to furnish the bridge with secret recognition signal reply, new reply being furnished at designated time of change. Immediately on sighting any vessel which has the appearance of a warship, the bridge flashes one series of "INT's". If no reply is received, report is made to watch officer for decision as to when further challenge will be made. Watch officer may direct bridge to flash a challenge at a given bearing before any vessel is in sight if radar on other fix gives probable location of an approaching warship and conditions indicate probability of signal lights being visible.

21. Correct reply to challenge is immediately acknowledged by bridge flashing "R". Incorrect reply is immediately reported to watch officer for action in accordance with paragraph 24b. Following acknowledgment of correct reply, bridge flashes "AA" for identification by exchange of calls. If no immediate reply is received to "A", bridge sends "AA V H3" twice and reports immediately any further delay by vessel in identifying herself to watch officer for action in accordance with paragraph 24b. If approaching warship is expected, she is allowed to proceed as traffic conditions and any special instructions permit, with notification to interested offices. If unexpected, watch officer will obtain permission from Surface Controller for her entry, and berthing information from Asst. Captain of Yard or ComBosec, before allowing her to proceed in from Outer Examination Area. Ordinarily an expected warship will consider exchange of calls as conveying permission to enter unless HECP signals definite instructions to standby outside. She has every right to expect favorable gate signals and clear channels unless advised to the contrary. Requests from expected warships to enter will be answered immediately by "Affirmative" or by definite instructions for delay. To avoid confusion and for reasons of security, berthing instructions will not be sent entering vessels until they are inside North Channel Fairway Buoy at

Point Baker. Warships which have previously visited Boston should have aboard SOPA letter on "Control of Traffic", but watch officers must be alert to signal any necessary instructions.

22. Should any vessel flash HECP the secret reply to challenge before she is challenged, bridge will immediately flash "INT" and expect a repeat of the reply.

23. Every effort will be made to expedite an entering warship consistent with her seniority and ordered priorities for others, in accordance with "Instructions for Control of Traffic", Annex C. When necessary to delay an entering warship, definite instructions will be signalled her together with reason for and estimated length of delay.

24. If a warship makes improper reply to challenge or fails to identfy herself to the complete satisfaction of watch officer, HECP will employ following procedure:

(*a*) If a warship fails to answer or makes improper reply to challenge by Examination Vessel, the latter will immediately send message to HECP consisting only of code words or groups indicating class of vessel and "Wrong reply" or "no reply." No further action will be taken by Examination Vessel unless HECP so directs or the approaching vessel demonstrates hostile intent. Watch officer must take into consideration:

(1) The possibility that entering vessel might not recognize the Examination Vessel as such and ignore a shore-to-ship challenge from her;

(2) the possibility of Examination Vessel making an error in looking up the proper reply to challenge;

(3) the fact that, although minor warships are required to reply to Examination Vessel's challenge, major warships are not;

(4) ignoring of Examination Vessel's challenge, because entering warship had previously replied direct to HECP. A "wrong reply" or "no reply" message from the Examination Vessel should put the watch officer on special alert unless or until correct reply has been received by HECP. Under no circumstances should an entering warship be allowed to proceed past the Examination Vessel which will then insist on correct reply to challenge and identification, and will pass full information to HECP by coded radio dispatch, detaining entering vessel near her until message is receipted for or further instructions obtained.

(*b*) If a warship fails to answer or makes improper reply to either challenge or request for call by HECP, the watch officer will prepare to bring her to in the Outer Examination Area for all necessary inspection to establish her friendly character and identity. In so doing, however, he will take into consideration and check the possibility of:

(1) HECP having posted the wrong reply to challenge;

(2) Bridge misreading the reply;

(3) Vessel not having received a recent change in recognition signal data;

(4) Surface Controller having failed to pass information regarding a new ship manned by civilians and not equipped with recognition signals;

(5) Inexperienced communication personnel aboard a vessel on trial runs or shakedown cruise. The length of time to be spent in checking these possibilities by telephone, repeated challenges and other signalling is a matter of judgment for the watch officer, depending on distance, visibility, speed of vessel, information on possible enemy activity, etc. However, he must keep the situation in hand so that by flag hoist and by flashing light from both HECP Examination Vessel the entering warship can be ordered to stop and standby in the Outer Examination Area. Any warship failing to obey such orders immediately is suspicious and to be so reported to Army watch officer. No suspicious warship should be allowed to approach beyond a point where she can be destroyed by Army mines or shore batteries. Warning shots may be ordered from Examination Battery or Examination Vessel. Any warship failing to heed warning shots and signals will be assumed to be hostile and so reported to Army watch officer, Surface Controller and ComBosec. Gate Vessels and all other elements of harbor defense will then be alerted and battle action taken as necessary to protect the port and its shipping. Surface Controller and any superior authority properly taking over control of the action will be kept informed of all developments.

Submarine and Motor Torpedo Boats

25. These vessels are handled in the same manner as any other in Port of Boston.

Navigation Lights

26. This is a directive of NDP–1A for vessels concerned. HECP must anticipate any degree of visibility or complete absence of navigation lights on approaching warships. Unless enemy activity in Massachusetts Bay is suspected, navigation lights should be used on vessels inside Point Charlie and they should be so advised if blacked out at night.

Net or Boom Gate Signals

27. (*a*) Deer Island Gate Vessels exhibit prescribed signals as ordered by HECP watch officer who is responsible for control of traffic through the Deer Island Gate, as set forth in "Instructions to Deer Island Gate Vessels."

(*b*) Moonhead Gate Vessel exhibits prescribed signals as shown above for Starboard Hand Gate Vessel during inbound movement and for Port Hand Gate Vessel during outbound movement, and sounds fog signals. These signals are displayed as ordered by officer-in-charge of gate vessel who is responsible for control of traffic through Moonhead Gate, as set forth in "Instructions to Moonhead Gate Vessel."

(*c*) Nut Island Gate Vessel exhibits prescribed signals for Starboard Hand Gate Vessel during inbound movement and for Port Hand Gate Vessel during outbound movement, and sounds for signals. These signals are displayed as ordered by officer-in-charge of gate vessel who is responsible for control of traffic through Nut Island Gate, as set forth in "Instructions to Nut Island Gate Vessel."

Merchant Shipping Procedure

28. The examination of merchant vessels entering the Port of Boston is an integral part of the defensive organization of the port and essential to the control of traffic required by HECP for safe and expeditious passage through channels and gates. Some transports and other vessels are provided with the Secret Recognition Signal Memoranda giving them the status of warships for entry.

29. The principal purpose for examination of merchant vessels is to determine identity and ascertain character and intentions, in order that the defenses may have warning of the attempted entry of suspicious or unfriendly ships. A second purpose is to expedite quarantine and customs clearance and arrangements for berthing, docking, loading, and unloading. The examination personnel also (1) make certain that merchant masters have requisite knowledge of chanels, gates and signals for safe entry; (2) seal radios; (3) make armament report; (4) give instructions regarding use of armament, boat etc.; (5) furnish any special instructions applicable to the current visit in the port.

30. In order that delay in the movement of entry, involved by examination, be reduced to the minimum, all entering merchantmen are categorically divided into three classes by decision of Assistant Examining Officer (Boarding Officer) as to whether (1) identification without inspection is sufficient to

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permit entry and passage to berth or dock; or (2) identification without inspection is sufficient to permit entry for examination inside the net defenses; or (3) examination should and will be made by boarding in Outer Examination Area; or (4) examination should be made outside but heavy weather or other adverse circumstances prevent boarding in Outer Examination Area, so coverage by shore batteries is desired during entry and until examination is completed by Assistant Examining Officer at Inner Examination Anchorage.

31. Control of traffic entering and leaving the port is based on CIP letter of January 1, 1942, as subsequently modified from time to time by directives on "Public Traffic Regulations—Port of Boston, Massachusetts."

32. Examination elements at Port of Boston are:

(*a*) Outer Examination Area which is understood to be the water within one-half mile of the Examination Vessel.

(*b*) Outer Anchorage which is the water area North and West of and more than one-half mile from the Examination Vessels regular station.

(*c*) The Examination whose regular station is at anchor 3000 yards 319° true from Graves Light. This vessel is armed and operates boarding boats.

(*d*) The Coast Guard Sub-Base (Ex-Boston Life Boat Station) moored off Fort Dawes Dock in Anchorage Two, President Roads. This vessel operates boarding boats.

(*e*) The Inner Examination Anchorage, being anchorage two in President Roads.

(*f*) The Inner Guardship stationed at Buoy 3 off Spectacle and Castle Islands, Inner Harbor.

(*g*) Assistant Examination Officers (Boarding Officers) stationed on Examination Vessel and Sub-Base.

(*h*) Examination Battery of 90MM guns at Fort Dawes, supported by other HECP alert batteries.

(*i*) Armed guards as required by Assistant Examination Officers supplied by COTP.

33. The Examination Vessel, Sub-Base Inner Guardship, and Boarding Boats are Coast Guard Vessels and manned by Coast Guard personnel. By agreement between COTP and CNLDF, the Examination Vessel is attached to and operates directly under command of Boston Section NLDF and Boarding Officers (Assistant Examination Officers) are to take instructions from HECP. Public Traffic Regulations have been issued jointly by CNLDF and COTP. Army has designated Battery 944, consisting of four 90MM guns located on southeastern tip of Deer Island, as the Examination Battery. Armed guards are Coast Guard personnel.

Procedure for Identification of Merchant Shipping

34. Incoming merchant vessels are admitted to Outer Examination Area at all times of the day or night.

35. No merchant vessel may proceed in or depart from the Examination Area without joint permission from HECP and the Assistant Examination Officer.

36. The detailed procedure to be followed with incoming merchant vessels is set forth in "Instructions to Examination Vessel and Boarding Officers."

37. Governing conditions are met as follows:

(*a*) Identification and any examination required outside the net defenses take place in the Outer Examination Area which is two miles inside the nearest Loop and well covered by shore batteries.

(*b*) Outside boarding when necessary is carried out in the Outer Examination Area which is three and one-half miles from Deer Island Gate. The Examination Battery and supporting batteries all have complete coverage of the Outer Examination Area and channels in. Army's North Minefield must be crossed on way in.

(*c*) Boston Pilot Vessel maintains station in all but heaviest weather between Point Zebra and Boston Lightship. In foul weather she may come in to Outer Examination Area or secure at Nahant or in Boston Inner Harbor. Boston pilots are Coast Guard Officers and contact may be made through Coast Guard District Headquarters or Navy Yard.

Incoming Merchant Vessels

38. Merchant vessels entering the port are required to report to the Examination Vessel. Anchored near the seaward end of the only channels open into Boston and Lynn, she is well located to contact entering vessels and is equipped with whistle and guns for attracting attention in case she is ignored. On completion of identification and such examination as may be necessary, Assistant Examination Officer requests permission for inbound merchant vessel to enter. This request is transmitted from Examination Vessel by visual signal if practical, otherwise by coded radio message. If HECP reply to request states that a delay is necessary, or if a negative reply is made because of closed port conditions, the Assistant Examination Officer passes full information to the merchant vessel. Any delayed vessel is given an opportunity to anchor or proceed to sea, unless other specific instructions are given by HECP.

HECP watch officer will not give affirmative reply to request to enter unless channel and gate conditions are favorable for entry without necessity for hazardous or inconvenient standing-by in channel. Every entering vessel will be kept under close observation or tracked by detection devices at HECP; so that identity as established in request from Examination Vessel is not lost during transit of channel and gate.

39. If an approaching merchant vessel disregards signals made to her by the Examination Vessel, the latter will inform HECP by urgent dispatch. Navy watch officer at HECP will then endeavor to turn the entering vessel back by flashing light signals. If unsuccessful he will request Army watch officer to bring her to by firing shot across her bow from Examination Battery. Unidentified or suspicious vessels must not be allowed to approach closer to the gate than North Channel Buoy 10.

40. Any merchant vessel approaching Deer Island without permission from the Examination Vessel should be turned back, but conditions of tide, wind and channel traffic may make this procedure impractical. If so, the vessel must standby, until HECP watch officers are completely satisfied as to identity and intentions through contact by signals or patrol boat. Anchoring should never be permitted in North Channel except in the most dire emergency due to cable areas and minefield. A vessel which cannot be returned to the Examination Vessel should be brought into Examination Anchorage in President Roads and kept covered by short batteries until cleared by Assistant Examination Officer from Coast Guard Sub-Base.

41, 42. Provisions of these paragraphs are incorporated in "Instructions to Examination Vessel and Boarding Officers."

43. If the Assistant Examination Officer decides that a merchant vessel is suspicious and should be given a further examination, he will so report to HECP with a request for coverage by shore batteries. The vessel will then be ordered to standby well clear of the Examination Vessel and of any friendly ships anchored in the Outer Examination Area, until armed guards can be put on board. If sufficient armed guards cannot be provided from personnel aboard the Examination Vessel, HECP will be notified and Navy watch officer will make arrangement with the Captain of the Port for necessary number of guards.

44. Shore Battery coverage is provided for any vessel declared

suspicious by an Assistant Examination Officer, until she is definitely cleared by dispatch from Examination Vessel or Coast Guard Sub-Base. While under suspicion, a merchant vessel must display special identification signals consisting of: The international flag hoist "TP" by day and a vertical display of one white, one red and one white light at night.

45. Provisions of this paragraph are incorporated in "Instructions to Examination Vessel and Boarding Officers".

46. If a merchant vessel without the special signal attempts to proceed inward from fairway buoy at entrance to North Channel (Point Baker) or to enter by other than North Channel, efforts will be made to turn her back by signals; but if she proceeds to within two miles of Deer Island Gate she shall be brought to the Examination Battery.

47. If Examination Vessel is unable, because of bad weather, to remain on station, the port will be closed to all except Naval vessels and vessels given special permission to move by CNLDF. These exceptions will be handled by direct signal from HECP. Small craft seeking refuge when port is closed may be directed to refuge moorings in lee of Gallups Island, if gate is closed or examination inside net defenses is impractical. Special opening of the gates, which are normally closed when port is closed, may be authorized by Naval Officer-in-Charge, HECP.

Lights to be Displayed by Merchant Vessels in Convoy when Approaching Examination Anchorages at Night.

48. Special identification of convoy vessels by two horizontal red lights is not necessary at this port.

Vessels in Tow

49. Tows without self-propelling equipment are reported as a unit with towing vessel. Tows which are ordinarily self-propelled are reported separately from their towing vessel with full information as to reason for towing.

50. Provisions of this paragraph are included in "Instructions to Examination Vessel and Boarding Officers."

The Object and Constitution of the Organization for Examination of Shipping

51. Examination of vessels entering Port of Boston is a function of the Captain of the Port who is an officer of the Coast Guard. By agreement with Commander Naval Local Defense Force, his Assistant Examination Officers, in addition to instructions from him regarding Coast Guard functions, receive instructions and operate under direction of HECP for the security of the port and shipping outside the net defenses. For smooth operation of this joint control, closest cooperation is essential and frequent interchange of visits by officers between HECP and the Examination Vessels is desirable.

52. All forces afloat, all port directors, all routing officers and all captains of ports have been advised that Port of Boston is a controlled port.

Examination Anchorages

53. Examination Areas and Anchorages at this port comply with provisions of this paragraph as follows:

(*a*) Outer Examination Area is the water area within one-half mile of Examination Vessel whose regular station is 3000 yards 319° from Graves Light. The area provides reasonable shelter for large vessels; in two and one-half years the Examination Vessel has not been forced off station by weather. Small vessels which are not wanted inside the net defenses may be sent in to take refuge at special moorings south of Gallups Island. The Outer Area is far enough away from the Deer Island Gate (3½ miles) and from the minefield (1 mile) to allow ample time for the defenses to deal with a vessel leaving the area with hostile intent before she could reach an objective. The Inner Examination Area is inside the net defenses in Anchorage Two in President Roads, where the Coast Guard Sub-Base is located.

(*b*) The Outer Examination Area is covered by the Examination Battery and supporting batteries as is the whole of the approach channel to Deer Island Gate. Searchlight illumination also covers these areas from Nahant, Fort Dawes and Fort Standish. The Inner Examination Anchorage is covered by 40MM guns and searchlight at Fort Strong, and its exits are covered by one 90MM and searchlight at Fort Dates.

(*c*) Both Inner Examination Anchorage and Outer Examination Area are clear of submarine cable and underwater defenses.

(*d*) Limits of Examination Anchorage and Area are not published, but Public Traffic Regulations gives position of Examination Vessel and channels to her.

Examination Vessels

54. A Coast Guard Relief Light Vessel, armed with 3" gun and machine guns, is assigned as Examination Vessel. She is equipped with a gig for boarding work, which is inadequate and obliged to seek shelter at Nahant in bad weather. No adequate boat has been available for boarding which requires a sturdy craft with heavy strakes and topsides built well inboard to operate in moderate to bad weather. (A so-called Torpedo Retriever would be the ideal boarding boat.) The Examination Vessel is well fitted with signaling and radio equipment. Accommodations are adequate for crew and examination officers, but pilots are not carried as they have their own vessel.

55. The Examination Vessel is anchored and the Outer Examination Area moves with her, being the water area within one-half mile. Her contact with Examination Battery is through HECP which controls it.

56. The Examination Vessel has been on retaining control without her sending entering vessels into Anchorage Five in Nantasket Roads for boarding outside the net defenses. This action would cause serious delays and only be resorted to in case a vessel was too suspicious to move into the Inner Examination Anchorage before boarding.

57. Examination Vessel is distinguished by the Union Jack flying at the truck. When port is closed by day she hoists in addition three red balls vertically at the yard arm. At night she displays three lights vertically six feet apart showing unbroken around the horizon. When the port is open, these lights are white; when it is closed they are red.

Examination Batteries

58, 59, 60. The 90MM battery on southeastern end of Deer Island at Fort Dawes has been designated by the Army Harbor Defense Commander as the Examination Battery. It is constantly on an alert basis and gets out its first shot within 50 seconds of order from HECP Army watch officer who controls it. Tracking of entering vessels is on his order. Both non-explosive and blank ammunition is kept available near the guns (but separate from the service ammunition) to be used for warning shots. Personnel of the Examination Battery are familiar with all channels, anchorages, and defenses; so that it can carry on with Battery or Gun Commander's action when necessary to pass control from HECP.

61, 62. The responsibility of opening fire with any shore battery rests with the Army, but by joint agreement of the Army and Navy Officer-in-Charge the fire controlled by HECP will only be used by consent of the Navy watch officer and the

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Army watch officer will give due heed to advice and requests of the Navy watch officer for firing. Requests of the Examination Vessel or any other Navy unit to "bring to" a vessel will be evaluated by the Navy watch officer who will request warning shots by shore battery from the Army watch officer as necessary. The responsibility for judging how soon a vessel should heave to after a warning shot because of tide, wind or traffic conditions rests with the Navy watch officer. Obviously intentional disregard of a warning shot, or definite recognition as a hostile vessel even before a warning shot, is sufficient reason for the Army watch officer to order fire for effect.

63. Being anchored the Examination Vessel is unable to maneuver, but her area is covered by several batteries from different angles; so fire at a vessel in her vicinity can be obtained without danger to her.

Communications Between Examination Vessel, Examination Battery and Harbor Entrance Control Post

64. The distance (3½ miles) between HECP and Examination Vessel makes signalling by flag hoist impractical. These two units call and answer each other by a series of "Z's" on directive flashing light. Unencrypted radio calls are used for radio telephone communication on 2150 kcs.

65. Communications are not maintained between Examination Vessel and Examination Battery since the latter is under direct control of HECP.

66. If the Examination Vessel wishes the Examination Battery to "bring to" an incoming vessel she will make the request by urgent dispatch to HECP. To avoid any chance of failure of this communication she will also make a succession of 2's by flashing light, hoist 2 pennant by day, and burn a blue light at night. These signals indicate only that the incoming vessel being dealt with is disregarding orders and that the Examination Vessel requests that she be "brought to."

67. Should any hostile action on the part of a merchant vessel or her crew be observed by the Examining Officer, she will send urgent dispatch to HECP and make a succession of 8's, hoist 8 pennant by day, and fire green Verys light or green rocket at night. These signals are alarms and call for fire from Examination Battery or supporting batteries.

68. Should it be necessary for an alarm signal to be made by the boarding officer, or by men in his boat alongside the vessels boarded, a green Verys light is to be used, the Examination Vessel repeating the signal by the same means and reporting by urgent dispatch. HECP watch officers should not wait for repetition by Examination Vessel to take necessary action.

69. In order to minimize damage, should fire be opened on a ship which subsequently is found to be friendly, the Examination Vessel will send HECP urgent dispatch in code to cease fire, make a succession of 4's by flashing light and hoist 4 pennant.

70. If there are other vessels present which might confuse HECP as to which vessel is referred to by signals prescribed in paragraphs 66, 67, and 69, the Examination Vessel will designate the vessel being dealt with by flashing three numerals giving her true bearing from the Examination Vessel. This bearing will be given immediately after the first succession of 2's, 8's or 4's and immediately before each subsequent alarm signal, thus: 2–2–2–2–2 236; 236 2–2–2–2–2–; 236 2–2–2–2–2 236 2–2–2–2–2–.

Closing of Port

71. Port of Boston as a Naval port is normally closed at night (from one-half hour after sunset to one-half hour before sunrise) and in thick weather (zero visibility). Because of necessity for moving fuel ships, Naval vessels and transports regardless of visibility, there are exceptions which may move with specific permission from HECP when signals indicate port is closed. Because of volume of traffic, it is necessary at times to have a complete or modified closing of the port in order to arrange orderly movement of scheduled convoys, transports, task forces, etc. The gates are kept closed when the port is closed to all vessels and normally closed with provisions for special openings during a modified closed port.

72. Minefields are habitually carried on "Signal" setting which is safe. Distances between Examination Vessel and outer line of North Minefield and between inner and outer lines of both fields allow ample time for setting on "Contact" in event of hostile action. All mines are Army type, controlled, ground mines, and casemates controlling them are under direct telephone or radio orders of HECP Army watch officers.

73. Watch officer HECP will order the port closed by dispatch to Examination Vessel, Inner Guardship, Nut Island Gate Vessel and Moonhead Gate Vessel and by telephone instructions to Coast Guard Sub-Base in President Roads and Deer Island Senior Gate Vessel. At the same time he will report the port is closed to Surface Controller of Northern Group and Commander Boston Section NLDF by telephone and confirm same by teletype to them and to District Coast Guard Officer, Captain of the Port, Commander Naval Local Defense Force, and Port Director. Modifications of closed port and partial or complete opening will be handled in the same way. Detailed instructions for closing the port or otherwise restricting movements under certain circumstances appear in Instructions for Controlling Traffic, Annex C. In general the degree of closed port and reasons therefor are as follows:

(*a*) "Port closed" to all vessels.—Emergency resulting from enemy action within Massachusetts Bay, accident to Gate Gear or to any vessel which might endanger further traffic, or a traffic jam which might endanger or delay a major or emergency Naval movement scheduled for a definite time.

(*b*) "Port closed except to Naval vessels."—Whenever traffic conditions require in order to move Naval vessels on scheduled time.

(*c*) "Port closed except to Naval vessels, fuel vessels and vessels having special permission from C NLDF."—This is normal night condition. Provisions are made for special permits.

(*d*) "Hold all traffic except convoy ships and vessels directly concerned with convoy movement."—Used to facilitate handling of either inbound or outbound convoys.

(*e*) "Hold inbound, clear channels for outbound."—Used to clear way for scheduled naval movements or transports outbound.

(*f*) "Hold outbound, clear channels for inbound."—Used to clear way for scheduled naval movements or transports inbound.

74. Watch officer HECP will not hesitate to close the port in emergency, but will keep ComBosec and Surface Controller fully informed with a view to immediate openings as directed by them for passage of war vessels out and of friendly vessels in for protection.

75. The standard signals to indicate port is closed are three red balls by day and three red lights at night vertically displayed by Examination Vessel so as to show all around, and she hoists one of these signals whenever port is partially or completely closed.

Ship to Shore Letter Signal and Special Signal

76. This paragraph in NDP–1A provides that the entry of ships which must be examined before entering is based on their identification to HECP by means of:

(*a*) The Ship to Shore Letter Signal held by all minor war

vessels. This recognition signal is used at Boston but otherwise minor war vessels are handled the same as major war vessels and not examined, so long as they have correct reply to challenge and are expected.

(*b*) The special signal given to merchant vessels which have been inspected and passed by Assistant Examination Officer. Vessels are passed by Assistant Examination Officer without inspection when they are positively identified as regular run coast-wise vessels flying a three-flag hoist issued by a Captain of an American port or as an expected routed ship flying a harbor number issued by the Port Director through the pilots.

77, 78, 79. The special signals are a combination of international code flags. Because no vessel may move in from the Examination Vessel without permission from HECP and entering vessels are easily tracked, it is unnecessary to use the combination of lights prescribed for special signals at night.

80. Local fishing boats are reported by Examination Vessel by type only and required to identify themselves at the Deer Island Gate Vessel and then proceed to Coast Guard SubBase in Inner Examination Anchorage for examination. They are individually logged and tracked in by HECP with identification by phone report from Gate Vessel.

Personnel Assigned to Conduct Examination of Vessels.

81. The personnel conducting examination of incoming merchant vessels and verifying clearance of outbound vessels are assigned by the Captain of the Port and are Coast Guard personnel.

82. The Captain of the Port assigns a roster of Assistant Examination Officers, known as Boarding Officers, who are continuously on duty at Examination Vessel and Coast Guard Sub-Base. Armed guards are supplied them as necessary by COTP from his Coast Guard personnel.

Pilotage

83. Boston harbor pilots are all commissioned officers in the Coast Guard under command of the Captain of the Port. They have full information regarding port regulations and channels. The Pilot Vessel is usually on station near Boston Light Ship. Should the Pilot Vessel be absent from station, or due to stress of weather be unable to place a pilot aboard, any master who is qualified, and who may elect to bring his vessel into port, is authorized to do so as far as the Inner Examination Anchorage. Coastal pilots are likewise authorized to bring in vessels to that point, and qualified masters of coastwise vessels are authorized to act as harbor pilots for their vessels. In general, pilotage at Boston is recommended and ordinarily used, but not enforced.

Notices to be Issued on the Enforcement of the Merchant Shipping Procedure.

84. Public Traffic Regulations provide adequate information for all intending to use the port.

85, 86. Minor war vessels are required to reply to shore to ship challenge of Examination Vessel and of HECP by the ship to shore letter signal but are otherwise handled in same manner as major war vessels at Boston. Examination Vessel is not required to report their movements, as Army harbor surveillance provides better coverage.

Prizes

87. Escorted prizes are to be handled as war vessels in company of their escorts; unescorted, as merchantmen.

Incoming Neutral and Allied War Vessels, and Hostile War Vessels Bearing Flags of Truce.

88. Neutral war vessels are to be handled in same manner as merchantmen with permission from HECP to enter only on approval of *CNG,* unless vouched for by escorting Allied war vessels when they are to be handled as warships in company with their escorts.

89. Allied war vessels not supplied with US Recognition Signal will be identified by Assistant Examination Officer at Examination Vessel and permitted to enter if expected by or on approval of CNG.

90, 91. A hostile war vessel desiring to treat under a flag of truce will be forced to standby out of channels northeast of the Examination Vessel and covered by shore batteries until dealt with under specific instructions from CNG.

Incoming Fishing and Other Small Craft

92, 93, 94, 95. Lobstermen, other small inshore fishermen and pleasure craft operate under license from the Captain of the Port and in areas defined by him with approval of Army and Navy authorities. Passages through gates are logged by Gate Vessels and HECP, but not reported by HECP as ship movements if local vessels. Passages through Examination Area are logged by Examination Vessel, but local boats are not reported to HECP unless transit of gates is intended. The Captain of the Port has Coast Guard patrols make frequent coverage of the inshore fishing area, which is also watched by HECP and Army harbor surveillance. Fishing vessels operating outside the approaches to the port are handled in all respects as merchantmen, as are yachts arriving from or proceeding to other ports.

Standing Operating Procedure, HECP, Fort Dawes, Mass.

SECTION I. GENERAL

ANNEX A

1. References

(*a*) NDP 1 A–1943.
(*b*) FO #5, HD Boston, 17 May 1944.
(*c*) GO #3, HD Boston, 15 Sep 1943.

2. Mission

(*a*) The HECP Boston is the central point for the coordination and joint operation of the Army and Navy elements of the harbor defense system to provide for the security of the Port of Boston.

(*b*) Its mission is to collect, evaluate, and disseminate information of surface, sub-surface, and aircraft activities in the defensive sea areas; to control unescorted shipping in the defense coastal area; and to take prompt and decisive action to operate the elements of this harbor defense in order to deny enemy action within the defense coastal area.

(*c*) In order to properly accomplish this mission, the HECP is jointly manned by the Army and Navy. This procedure will outline the plan and duties of the Army phase of control.

3. Organization

(*a*) *Personnel—General.*—(1) Commissioned and enlisted personnel will be as per T/O 4-260-1, 1 April 1942, for a Harbor Entrance Control Post; with such variations as may be authorized by appropriate Tables of Organization; Allotments of Grades and Ratings; or by the Commanding General, Harbor Defense of Boston. Initially, such personnel will consist of the following:

No.	*Grade*	*Duty Assignment*
1	Lieutenant Colonel	
3	Majors	
1	(Optional)	
5	Sergeants	
1	T/4 Grade	H. D. Surveillance Officer
4	Corporals	Liaison Officers
2	T/5 Grade	Liaison Officer
6	Privates First Class	HECP Section
6	Privates	
1	Technical Sergeant	
1	Staff Sergeant	
1	Sergeant	
2	T/4 Grade	
1	Corporal	
4	T/5 Grade	

b Harbor Defense Surveillance Officer.—(1) The senior Coast Artillery Officer assigned and present for duty with the HECP is designated as the Harbor Defense Surveillance Officer. He is directly responsible for the proper administration, training, and operation of all Army personnel assigned or attached to the HECP. In the event of absence of the HD Surveillance Officer from the Harbor Defenses of Boston, the next senior Coast Artillery Officer present for duty with the HECP will assume the duties of the HD Surveillance Officer, in addition to his other duties, during such period of absence.

(2) By direction of the Commanding General, Harbor Defenses of Boston, the HD Surveillance Officer will supervise and coordinate the activities of the HECP, Sandwich, Mass.

(*c*) *Liaison Officers.*—(1) The four liaison officers assigned or attached to the HECP will have no other duties. They will perform as duty officers on a rotating schedule of eight continuous hours on watch with a twenty-four-hour relief between watches. This plan provides a rotating feature so that officers perform duty on a different watch each day, the cycle repeating itself every fourth day. For reference purposes, the watches are designated as follows:

0000 Q to 0800 Q—Mid Watch
0800 Q to 1600 Q—Day Watch
1600 Q to 2400 Q—Evening Watch

(*d*) *Enlisted Personnel.*—(1) Enlisted personnel assigned or attached to the HECP will have no other duties. They will perform duty with such section to which they may be assigned by the HD Surveillance Officer. Four complete sections will operate throughout a 24-hour day. The day is divided into four watches of unequal periods which are designated as follows:

0000 Q to 0630 Q—Mid Watch
0630 Q to 1130 Q—Morning Watch
1130 Q to 1700 Q—Afternoon Watch
1700 Q to 2400 Q—Evening Watch

(2) Each watch will have on duty a complete section which will consist of:

1	Signalman	From HECP Section.
1	Switchboard Operator	From HECP Section.
1	Teletype Operator	From HECP Section.
1	Observer	From HECP Section.
1	Recorder	From HECP Section.
2	Radar Operators	From Special Radar Section.

(3) In addition to four sections similar to that outlined in paragraph 3d (2) above, the following positions will be manned by personnel of the HECP and Special Radar Sections:

1 Administrative Chief of Section.
1 Alternate HECP qualified all positions. From HECP Section.
1 Cook.
1 Cook's Helper.

1	Radar Chief of Section	From Special Radar Section to the extent available.
1	Radar Repair Man	From Special Radar Section to the extent available.
2	Alternate Radar Operators	From Special Radar Section to the extent available.

4. Administration

(*a*) *General.*—(1) All administrative matters pertaining to the HECP will be routed through Headquarters, Harbor Defenses of Boston.

(*b*) *Commissioned Personnel.*—(1) Commissioned personnel attached or assigned to the HECP are directly responsible for administrative matters which pertain to them as individuals. This responsibility will include pay and allowance accounts, travel vouchers, allotments, etc. Though these matters may be processed by any headquarters or section, as a convenience, it is the responsibility of the officer concerned to insure their proper preparation, correctness, and submission.

(*c*) *Enlisted Personnel.*—(1) Enlisted personnel assigned or attached to the HECP will be administered in all personnel matters, excepting passes and furloughs, by such unit as is designated by the Commanding General, Harbor Defenses of Boston. The control of passes and furloughs is vested in the HD Surveillance Officer, subject to such limitations as may be imposed by higher authority as to percentage of personnel that may be on pass or furlough at any time and the length of such passes or furloughs.

(2) The Administrative Chief of Section will perform the duties of the Acting First Sergeant. Under the supervision of the HD Surveillance Officer he will maintain a schedule of reliefs to provide an equitable performance of duty by all sections. He is directly responsible to the HD Surveillance Officer for the cleanliness, care, and maintenance of all buildings occupied by the personnel of the HECP.

(*d*) *Quarters and Subsistence.*—(1) Commissioned personnel will be quartered at Fort Dawes unless permission to live off the post has been given by the Harbor Defense Commander. By agreement with the Navy, the Army officer actually on watch may procure such lunch as is available for serving from the Navy General Mess, and will pay for same to the Treasurer of the Navy General Mess. Lunches will normally consist of soups, sandwiches, and dessert.

(2) Enlisted personnel will be quartered in designated buildings at Fort Dawes, which will be referred to as "HECP Barracks." By agreement with the Navy, enlisted personnel of the HECP will be subsisted in a Navy General Mess established at Fort Dawes. To provide its share of the operating overhead, the Army will provide a cook and a cook's helper for this Navy General Mess.

5. HECP Surveillance Elements

(*a*) The elements at the disposal of the HECP are those as indicated in Annex No. 1 to Field Order No. 5, Hq. HD of Boston, 17 May 1944, and include:

(1) Artillery:

(*a*) Btry 206, East Point, Mass., two 6" BC; two 40 mm.

(*b*) Btry 941, Fort Revere, Mass., two 90 mm; two 37 mm.

(*c*) Btry 944, Fort Dawes, Mass. (Examination Battery), two 90 mm.

(2) Searchlights:

(*a*) SL—13, Point Allerton, Mass.

(*b*) SL—15, Fort Standish, Mass. (North End.)

(*c*) SL—22, Fort Dawes, Mass. (Examination Light.)

(*d*) SL—25, East Point, Mass.

(3) Observation Posts:

(*a*) OP 261, Fourth Cliff, Mass.

(*b*) OP 262, Point Allerton, Mass.

(*c*) OP 265, Fort Warren, Mass.

(*d*) OP 273, East Point, Mass.

(4) Range and Direction Finding Equipment:

(*a*) SCR 582 (installation 136) HECP, Fort Dawes, Mass.

6. Additional Elements Under Partial Control of HECP

(*a*) Additional Harbor Defense elements which are under partial control of HECP, and whose relationship is explained elsewhere in this SOP are:

(1) North and South Mine Field.

(2) Harbor Defense Radio Net.

(3) Harbor Defense Meteorological Station.

(4) SCR 268 Surveillance System.

SECTION II. PROCEDURES

1. General

a. The procedures herein outlined will govern conduct and transaction of all matters in which this station is concerned. Commissioned and enlisted personnel will adhere to this procedure unless deviations are authorized by the Commanding General, Harbor Defenses of Boston, or by the Harbor Defense Surveillance Officer. When the exigency of a situation necessitates variation from standing procedures, departure from the routine prescribed is authorized for the period of such emergency, and common sense measures which will successfully and expeditiously handle the situation will be employed. After passage of the emergency period, prescribed procedure will again be in effect.

2. Reliefs

a. An officer going on watch will report fifteen minutes prior to scheduled time of relieving his predecessor. Before relieving his predecessor he will insure himself that he is fully cognizant of all activity on which action is pending in order that he may carry the action to the proper conclusion. Immediately upon relieving an officer, the log will be signed by the officer taking the watch. Entry will show the name of officer being relieved. This entry is indicative of the fact that the relieving officer is fully informed of the current and past situation, and that he has assumed the responsibility of the watch. In no event should an officer relieve his predecessor until he is fully satisfied that he is in possession of all the information necessary to carry out an efficient watch.

b. Enlisted personnel of the HECP section is organized into reliefs for the purpose of manning the station. The responsibility of organizing the sections is vested in the administrative chief of section, subject to the approval of the Harbor Defense Surveillance Officer. Each relief will have a section chief who will be responsible that his relief is at the station in time to relieve the preceding section. The chief of section being relieved and the chief of section that is relieving will report to that effect to the Army duty officer on watch. The chief of section is responsible for the conduct and efficiency of all personnel in his section. He is responsible that his section is capable of performing its assigned duties, and will report any deficiencies, misconducts, etc., to the administrative chief of section for necessary proper corrective action.

3. HECP Army Duty Officers Log

a. An HECP Army duty officer's log sheet is to be kept, and in it is to be recorded all information of activity which takes place, is observed, or is reported, and which may be of information to the Army or Navy in the conduct of the operation of this station. At 0000 each calendar day a new log is started with the status of all mine fields given to Navy duty officer, and is continued for the full 24-hour period of the day, being closed at 2400. It is to be impressed that when in doubt as to whether information should be logged, the Army duty officer will be governed by the rule, "When in doubt—enter it in the log."

4. Mine Casemate Reports

a. Each hour, the enlisted men on duty at the North (Fort Dawes), Brewster (Great Brewster Island), and the South (Fort Warren) Casemates will call this station by direct wire, and report the condition of the mine fields. Mine fields may be set on signal, semi-automatic, or automatic. Each hourly report will be entered in the log; entry will show the station, time, and condition of the mine field together with the name of the person making the report. It is quite important that the officer receiving the report be positive as to the condition of the mine fields. The normal setting is "On Signal." This setting will register a vessel passing over the field but it will not explode the mine.

b. Mine contact reports (Armings).—When a signal is registered on a mine, the casemate will notify Army duty officer, giving time, mine group, and particular mine or mines on which such signal was registered. This information will be logged, and an evaluation made. Evaluation entry will be made on the log. Example: BMF 2020 Contact Gp. 18 Mine 4 HOGAN, Tug & Tow Outbound—Pvt. Flick. In the event of darkness or poor visibility, use will be made of searchlights or Radar to aid in evaluation, if necessary. The casemate reporting the contact will be advised of the evaluation made.

c. Status of Mine Groups.—At 0830 each day, the Army duty officer will, by phone, contact each casemate and obtain information as to the status of all mine groups and sound ranging apparatus. This information will be logged and kept on a reminder sheet. The reminder sheet will have noted any group or mine, or other equipment which is inoperative, and the date and time it became inoperative, and the reason.

d. Spurious or Constant Arming of Mines.—Due to tidal, wave, or atmospheric conditions, there are times when mines will give spurious (false) or constant signals. These will be reported to the Army duty officer by the casemates. If they are evaluated as such, they will be logged and such evaluations will be shown.

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e. Control of Mine Fields.—If the casemate requests authority to put any mine field, mine group or individual mine out of action for any reason whatsoever, it will be advised that it must secure permission from the mine group commander.

f. Changes in Condition of Mine Group Settings.—Any change in the condition of a mine group setting, or any individual mine setting will be logged, and the S-2 Harbor Defenses of Boston and the Navy duty officer will be notified. There must be a constant exchange of information with Navy personnel to provide for effective operation and harmony. Changes will be logged in the Army duty officer's log, together with the information as to whom the data was furnished.

5. Surveillance of Shipping

a. The observation station listed in Section I, Para 5 a (3) of this paper will report all shipping which is observed to approach the Port of Boston. This information will be logged, together with all available information, in the appropriate columns of the log sheet.

b. Illumination of Vessels Approaching Gate Entrance to Boston Harbor.—All vessels, except friendly Naval vessels, and transports (Army or Navy) will be followed by a searchlight beam slightly astern of the vessel. The searchlight at this station will be employed for that purpose and will be brought into action on orders of the Army duty officer. This light will not be illuminated until the stern of the vessel, or the stern of the tug, if it is a tug with tow, is well clear of the line from this station to Graves Light, and will be extinguished when the vessel has cleared the entrance to the narrows. Light will be employed at an even pace over the channel while the observer scans the water area through the observer's instrument located in this station—noting any unusual objects, etc., which may be in the waters of the channel. After the light has tracked the vessel to the narrows entrance, it will be swept back over the channel, and all water area within the limits of the channel between the narrows and line from this station to Graves Light will be observed. Log entries will be made of time light was ordered in and out of action, and name of vessel for which it was employed. Example: SL-22 2020 In Action for Plymouth —Collier—Out of Action at 2032.

c. Reports From OP 265—Fort Warren.—The OP at Fort Warren is employed to keep the Army and Navy informed of approaches to the gate of all shipping from the inside southerly section of Boston Harbor. All information will be logged and the information passed on to the enlisted observation duty and to the Navy duty officer. As an additional function, OP 265 may be employed as a sub-signal station of the HECP to relay or receive visual messages from vessels in its area of observation.

6. Opening and Closing of the Port of Boston

a. At the discretion of the Navy duty officer, the Port of Boston may be declared closed for reason of poor visibility, special movements inbound or outbound, scheduled firings, etc. In such event log entries will be made.

7. Alerts of Surveillance Elements

a. A schedule of specific and general alerts of HECP surveillance elements is prepared monthly. On day previous to scheduled alert, the administrative chief of section will prepare a check sheet of units to be alerted, showing the time, unit to be alerted, and whether or not the Officer of the Day is required to be present. The officer on watch will notify the Commanding Officer or Adjutant of the post on which unit is to be alerted in cases where the Officer of the Day is required to be present. He will give the unit to be alerted the scheduled time of the alert, and information that the Officer of the Day will be required to be present. In cases where no Officer of the Day is to be present, no information of the alert will be given to anyone.

b. Conduct of Alert Tests.—At the proper time for alerting a unit, the Army duty officer will call the unit by direct line and will identify himself to the party answering; then directing that the unit be alerted and report made to HECP when in order. Times of calling the alert, of the unit reporting its standby gun crew in order, and time of the complete battery being reported in order will be entered on the check sheet, together with any remarks that may be appropriate. After complete unit has been reported in order the Army duty officer will advise units that it was a test alert, and direct that station be closed and unit returned to normal alert status. In cases where the Officer of the Day is required to be present, the Army duty officer will ask for the Officer of the Day after the complete unit has been reported in order. He will identify himself to the Officer of the Day and advise him that it was a test alert. He further advises the Officer of the Day that HECP is through with the unit and directs that after the Officer of the Day has finished with the unit he have it close station and return it to a normal alert status. In the cases of the searchlight alerts, the Army duty officer may order the lights into action for a short period of time in order to insure that units are actually in order. Care should be taken that when these lights are ordered into action, no shipping of any kind, nor any installation of the Army or Navy are inadvertently illuminated.

c. Alerting of Battery 944 (Fort Dawes) for Challenging Purposes.—In the event the Navy duty officer requests that Battery 944 be alerted for the purposes of challenging an unidentified or suspicious vessel, the procedure outlined in b above will be followed. However, at the discretion of the Army duty officer, the battery may be advised to alert only one gun crew instead of the complete battery. The noncommissioned officer in charge of the standby gun crew of Battery 944 will be advised of the reason for alert, and gives such other information as will enable him to provide effective action. *Authority to open fire is vested in the Army Duty Officer.* Separate instructions covering this authority are contained in Secret Letter from Headquarters Harbor Defenses of Boston, and copy letter is at all times stored in the Army duty officer's desk. A chart showing designated fixed firing points is also available to the Army duty officer at the desk.

SECTION III. MISCELLANEOUS ACTIVITIES OF HECP

1. General

a. This station is charged with miscellaneous activities, not an integral part of a Harbor Entrance Control Post. Personnel of this station will carry out instructions concerned with these miscellaneous activities with the same spirit of successful execution as is employed in the normal duties of HECP personnel.

2. Meteorological Station

Meteorological station of the Harbor Defenses of Boston is located in the buildings of HECP. One enlisted man of the Artillery Engineers Section, Harbor Defenses of Boston, is detailed as meteorologist. In the execution of his duties he is assisted by the enlisted personnel of this station as may be directed to do so by the administrative chief of section.

3. Harbor Defense Radio Net Control

Personnel of the Harbor Entrance Control Post will maintain a constant radio watch on the Harbor Defense Radio Net,

and exercise net control except when it is specifically taken over by the Harbor Defense Command Post. Net control check calls will be made from this station hourly—but at not specified time. Reports of discrepancies, failure to answer calls, etc., will be made by radio operators to the Army duty officer, who will take the necessary action to correct deficiencies.

4. Additional Duty as Harbor Defense Watch Officer

Daily from 1630 until 0830 the following morning the HECP Army duty officer will act as the Harbor Defense Watch Officer, and similarly all day on Sundays and holidays. During this period he is the direct representative of the Harbor Defense Commander, and as such will act for him in accordance with separate instructions issued as memorandum from Headquarters Harbor Defenses of Boston, Subject: Additional Duties of the HECP Army Duty Officer. The Army duty officer will take particular pains that in instances where he acts for the Harbor Defense Commander, the staff duty officer on call at Fort Banks is immediately advised of any situation which is not of a routine nature. Careful log entries will be made of any action, communications, etc., made by the Army duty officer for the Harbor Defense Commander, and these will be reported to the proper parties immediately after the open of business each day at Harbor Defense Headquarters.

5. Liaison With HECP Sandwich, Mass.

Close liaison will be maintained with the Harbor Entrance Control Post at Sandwich, Mass. That station is a function of the Harbor Defenses of Boston, and is supervised by the Harbor Defense Surveillance Officer. All information of any nature which will be of interest to HECP Sandwich and the Coast Guard personnel associated with it will be transmitted without delay. This information will include complete information of all merchant shipping which will transit the Cape Cod Canal, notifications of Bombing Missions conducted by planes, and any information of scheduled firings will be of value to HECP Sandwich in control of shipping from that point. Similarly, the HECP Sandwich will relay all information of like character to this station. Information will be carefully logged and properly disseminated. All reports of shipping which is routed to Boston Harbor Forts will be given to the enlisted observer who will plot same on a chart, this to be used as a ready means for determining the amount of shipping which is in transit to this port.

NOTE: DO NOT REPORT MOVEMENTS OF ANY TYPE.

ANNEX "B"

Navy HECP Organization Book

(Arranged according to NLDF standard form)

Chapter I

Assignment of Officers

The Navy Officer-in-Charge, will be so designated by the Commander, Naval Local Defense Force, and will be responsible to the Commander Boston Section for the proper functioning of the Naval personnel and equipment. He will be available on one hour's notice at any time. He will stand watch in emergency and be responsible for instruction and supervision of other officers. He will act as Commanding Officer of naval personnel attached to HECP.

Four officers will constitute the assistant watch officer list.

Naval officers attached to HECP are entitled to use of the officers quarters at Fort Dawes. Mess bills there are payable monthly to the Mess Treasurer.

In emergency one bunk in officers' emergency stateroom is available for use by the naval officer attached to HECP, but this room is not available for living quarters.

Naval officers attached to HECP are entitled to first consideration in the use of the post's station wagons for their transportation to and from the post for duty as far as the terminal of Rapid Transit or the Section Base in East Boston.

Assignment of Crew

There will be two Chief Petty Officers, one of whom will be on duty as master-at-arms, responsible for maintenance, watch lists, musters, return of liberty parties, operation of beach wagons and truck, barracks maintenance, drills, and direction of work parties. One CPO will be responsible for all signal gear, and another, for all radio equipment.

The cook will be responsible to the CPO on duty for all galley gear and the requisition and preparation of food for the mess. He will be assisted by a second cook and striker from the Naval detachment and by one cook and one KP from the Army detachment.

One senior signalman shall be assigned to a special daytime duty, making an extra signalman on the bridge during rush hours and assisting in instruction and care of signal gear in slack periods.

An Electrician's Mate (or RM or RT so assigned) shall be assigned to radio and electrical maintenance work and his liberty so arranged that he will be on duty during any absence of the CRM.

When two yeomen are attached to the post, they will stand alternate days, one being available from dawn to dusk. When only one yeoman is attached to the post, he will conform to office working hours of the district. A yeoman shall be on duty at the post during district office hours unless sent on specific duty outside.

The rest of the crew will be divided into six sections. Watch sections shall have a minimum complement as follows:

1 Signalman—for signal duty on the bridge.

1 Signalman—or striker for signalman—for signal duty on the bridge.

1 Signalman—or striker for signalman—for observer in Observation Room.

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1 Radioman—for radio watch in radio room.

1 Radioman—or striker for radioman—for radio watch in radio room.

1 Radioman—or striker for radioman—for watch on Loop and Hydrophones.

The post's complement is as follows:

1 CBM	5 SM3c	1 RM1c	1 F1c
1 Cox	11 S1c	1 RM2c	1 Y1c
1 CSM	10 S2c	2 RT2c	1 Y3c
2 SM1c	1 EM1c	1 RM3c	1 SC1c
3 SM2c	1 CRM	1 MoMM2c	2 SC3c

Chapter II

Organization of Departments

Signal and Observation:
- 1 CSM
- 2 SM1c
- 3 SM2c
- 4 SM3c
- 8 S1c

Yeoman:
- 1 Y1c
- 1 Y3c

Galley Crew:
- 1 SC1c
- 1 SC3c

Boat Crew:
- 1 CBM
- 1 Cox
- 1 SM3c
- 2 S1c
- 1 MoMM2c
- 1 F1c
- 1 SC3c

Radio:
- 1 CRM
- 1 EM1c
- 1 RM1c
- 1 RM2c
- 2 RT2c
- 1 RM3c
- 1 S1c
- 6 S2c

Loop, Hydrophones, etc.:
- 4 S2c

Watch Quarter and Station Bill

One CPO shall be on duty at all times. He will be in charge of the barracks and supervise work parties, drills and watches. He will be available to assist the watch officer at the station when called.

One yeoman shall be on duty during district office hours.

A ship's cook and striker shall be on duty or on call in the barracks at all times.

Boat crew will be organized as shown in Chapter VII.

Balance of crew will be divided into four sections, minimum for each of which will consist of:

2 Signalmen on Bridge.

1 Observer in Observation Room.

2 Radiomen in Radio Room.

1 Loop Recorder and Hydrophone Operator. Trainees divided among sections.

Chapter III

Nomenclature of Decks

1. Observation Room:

a. Army watch officer's desk on platform—phone call "Army watch officer."

b. Navy watch officer's desk on platform—phone call "Navy watch officer." Executone call "Control."

c. Loop and Hydrophone watch—phone call "Loop Recorder."

d. Observers—phone call "Observers."

e. Switchboard—phone and executone call "HECP."

f. Teletype.

2. Chart Room:

a. Army Surveillance Officer's desk.

b. Navy Officer-in-Charge's desk.

c. Communication desk.

3. Radio Room—Executone call "Radio."
4. Radar Room—phone and executone call "Radar."
5. Bridge—phone and executone call "Bridge."
6. Radar Blister—antenna shelter.
7. Signal Mast.
8. Conference Room.
9. Officer's Emergency Stateroom.
10. Boiler and Generator Room.
11. Army Barracks—phone "Army Barracks."
12. Navy Barracks—phone "Navy Barracks."
13. Mess Hall—phone "Mess Hall."
14. Meteorological Unit—phone "Fort Banks—Net Station."

Quarters for Muster and Inspection

All Naval personnel on the post but not on watch will muster for inspection Saturday at 1000. Inspection of personnel will be made in naval barracks. Immediately afterwards men will stand by their lockers for inspection of quarters.

Muster of work section and afternoon watch will be held in barracks or mess hall on week days except Saturday and holidays at 0830.

CPO having the day's duty will be responsible for muster and furnishing complete watches and will make immediate report of any discrepancies to watch officer.

Chapter IV

Berthing Bill

Rooms in barracks will be assigned according to seniority. Those not berthed in rooms will be berthed by section with first and third sections on lower deck, second and fourth sections on top deck.

Air Bedding

Chief Petty Officers will provide opportunity to air bedding on every fine day. Senior Chief Petty Officer will be responsible for each man taking advantage of these opportunities often enough to insure clean, healthful conditions.

Peacoat, Rainclothes, Bag and Suitcase Stowage

Shall be assigned by Senior Chief Petty Officer utilizing available closets, dry room and outhouse.

Assignment of Lockers

Senior Chief Petty Officers will assign lockers. Each man will be entitled to at least one steel clothes locker.

Chapter V

Cleaning Bill

Afternoon and evening watches will clean quarters daily at 0800.

Two men from the work section will be detailed each morning to assist in cleaning the station.

Friday will be field day with opportunity for cleaning clothes and bags after the station and barracks are in order.

Chief Petty Officer having duty will be jointly responsible with Senior Army Non-Commissioned Officer for assigning detail for the proper cleaning of HECP Mess Hall, and Recreation Building.

Chapter VI

Messing Bill

HECP mess is a Navy General Mess, supplied from Boston Section Supply Department, National Docks, East Boston, Mass.

Army enlisted personnel attached to HECP are carried as regular members of this mess.

Chief Petty Officer having duty will be jointly responsible with Senior Army Non-Commissioned Officer for proper operation of the Mess and supervision of cooks.

Boats

1. Disturbance II is assigned to HECP for police, communication and transportation duties in connection with control and security of Boston harbor. As such she is subject to the orders of watch officer, HECP only. Requests for assistance by any other element of the Harbor Defenses (Gate Vessels, Examination Vessel, Inner Guardship, Army Forts, Army Boats and officers attached to any of them) will be promptly reported to watch officer, HECP, who will make every effort to acquiesce so long as such assistance will not interfere with Disturbance's proper duties. She is not, however, a running boat and trips up harbor other than for necessary fuel and supplies are not to be encouraged.

2. Disturbance's station is the mooring buoy outside the Deer Island Gate, but for necessary lee and shelter she has permission to use any of the Army fort docks or Rice's Wharf. Permission will be obtained from watch officer HECP before moving from mooring or berth except in emergency and then full report will be made immediately to him.

3. Radio watch will be maintained on traffic control frequency at all times while underway, but radio will ordinarily be secured while at mooring or dock. Visual watch will be maintained at all times. Since orders to Disturbance will usually be of an emergency nature and prompt action required, radio-telephone will be immediately resorted to in avoiding communication delay.

4. CPO or PO in charge will report each morning as near 0800 as practical to HECP, preferably by visual signal or telephone:

a. General condition of vessel and gear.
b. Number of crew aboard.
c. Names on liberty parties returning and leaving at noon.
d. Amount of fuel.
e. Condition of engines and batteries.
f. Request for docking for supplies and nature of supplies required.

5. CPO or PO in charge will personally inspect vessel and equipment prior to 0800 daily and check report of engineer.

6. Engineer on duty is responsible for care and continued performance of engines, generator and batteries. He will initiate all steps necessary to insure proper running of the vessel by maintenance work, minor repairs and memoranda to the CPO or PO in charge regarding other required repairs or parts. He will inspect and report to CPO or PO in charge daily before 0800 on amount of fuel, lubricants and condition of engines, generator and batteries. His responsibility for the batteries include use of any electrical elements requiring power from the vessels' source of supply.

7. Disturbance will be inspected every Saturday as near 1100 as practical by the Officer-in-Charge, HECP or his representative.

8. Disturbance complement is included by Bureau of Personnel in that of HECP and records are maintained at Boston Section Base, Lockwood Basin, East Boston. Except in emergency, medical attention will be obtained at the Section Base by arrangement through watch officer HECP.

9. A crew of five including CPO or PO in charge will be aboard Disturbance at all times. When emergencies arise with respect to personnel, necessary substitute will be supplied by watch officer HECP. The vessel is not to operate without a crew of five except by specific order of watch officer HECP.

10. Complement of Disturbance is established as follows:

Number	*Rating*	*Duties*
T–1	CBM or BM	In charge while on board.
T–2	BM or Cox	Assistant to T–1 and in charge in his absence.
T–3	MoMM2c	Engineer.
T–4	F1c	Assistant to T–3 and engineer in his absence.
T–5	SM3c	Signalman, deckhand, and radio operator.
T–6	Sea	Signalman, deckhand, and radio operator.
T–7	Sea	Signalman, deckhand, and radio operator.
T–8	SC	Cook and deckhand.

11. Liberty will be arranged as far as practical by the CPO or PO.

Liberties will not be traded except with specific approval of Officer in Charge, HECP.

Liberty will commence as near 1200 as practical to put men on shore or on running boat.

12. CPO or PO in charge will assign billets and quarters.

13. CPO or PO in charge will assign station for each billet and post Watch Quarter and Station Bill after approval by Officer in Charge, HECP.

14. One drill shall be held each day so that within any period of three weeks every member of the crew will have participated in drills for battle, fire, man overboard, collision, and abandon ship.

15. Mess on Disturbance is general mess as provided from Boston Section Supply Department, National Docks, East Boston. The cook will be responsible for requisition and preparation of supplies under direct supervision of CPO or PO in charge. Supplies may be brought out by running boat or HECP automotive equipment.

16. Ship's supplies including fuel will be arranged for by CPO or PO in charge direct with proper Section Base authorities or through HECP watch officer.

Chapter VIII

Provisioning:

The senior cook will be responsible for adequate and satisfactory provisioning of the mess. The post's station wagon or other automotive equipment will be used as necessary for provisioning.

The Senior Chief Petty Officer will be jointly responsible with Senior Army NCO for maintaining adequate supplies of fuel for heating and cooking at the station and barracks.

Chapter IX

Fire and Rescue Party

Fire and Rescue Party will be ordered when necessary by Naval watch officer. Call will be by passing the word at the Naval barracks. Party will consist of all men available at Naval barracks not in the standby watch. Chief Petty Officer having the day's duty will designate the Petty Officer in Charge.

Chapter X

Fire Bill

In case of fire all available men will fall in at the HECP barracks in charge of CPO having day's duty. Call will be by firing salute gun and passing the word. Fire in or near the HECP barracks will be fought at once by this party and alarm telephoned or carried by messenger to the station and Fort Dawes Headquarters. Fire party will leave vicinity of Naval barracks to fight fire only on order of watch officer or Fire Marshall.

Chapter XI

Collision Bill

None.

Chapter XII

Abandon Ship Bill

None.

Chapter XIII

Lookouts

Men on observer watch in Observation Room will keep a sharp lookout on North Channel, the Narrows, adjacent water area, and that part of President Roads within one-half mile of Deer Island Net Gate. Men on the Bridge will keep a sharp lookout on President Roads and Boston inner harbor for traffic conditions and all around watch for signals. Lookouts are responsible for keeping the watch officer informed of all traffic, conditions of gate, signals from ships or other stations, and all unusual conditions. Position of traffic may be designated in relation to specific buoys or lights, but true bearings and estimated range will be required for any unusual or suspicious vessels or objects. Watch officer or observer should check orientation of Army Azimuth instrument in Observation Room and Azimuth Circle of 24" Blinker Searchlight on Bridge; Army watch officer will be requested to correct former as necessary, while latter will be serviced by CPO in charge of Signal Gear. Full advantage will be taken of Visual School at Section Base for determining qualifications of lookouts.

Chapter XIV

Towing Bill

None.

Chapter XV

Battle Bill

Upon call for a battle alert of the station the standby watch will assemble immediately in the Conference Room of the station in charge of the Chief Petty Officer having the day's duty. Other men on the post but not on watch will assemble under arms at the Naval barracks in charge of the Senior Petty Officer present, who will report for orders to Fort Dawes Headquarters.

CHAPTER XVI

Landing Force Bill

None.

CHAPTER XVII

Divisional Duties and Details

Signal gang will be responsible for care and condition of signal gear.

Radio gang will be responsible for care and condition of all electrical gear.

Galley crew will be responsible for care and condition of all galley and mess gear.

Yeomen will be responsible for care and condition of all files, typewriters and other office equipment.

Work section of the day will be responsible for care and condition of quarters, recreation room and all other equipment.

CHAPTER XVIII

Ship's Routine

0530—Morning watch turns out.
0550—Breakfast for morning watch.
0615—Morning watch relieves mid-watch.
0700—Afternoon and evening watches turn out.
0715—Breakfast for mid, afternoon and evening watches.
0800—Muster work section and afternoon and evening watches.
0835—Work section turns to.
1105—Work section knocks off.
1130—Dinner for all hands not on watch.
1155—Afternoon watch relieves morning watch.
1200—Dinner for morning watch.
1300—Work section turns to (drills in—no work).
1600—Work section knocks off.
1630—Supper for all hands not on watch.
1650—Supper for afternoon watch.
2400—Mid-watch relieves evening watch.

CHAPTER XIX

General Orders for Officers

A. *Watch Officer's Duties:*

1. Command the Naval detail on watch, supervising and directing the routine of signaling, identifying and reporting.

2. Coordinate the duties of the Naval detail on watch with those of the Army detail through close cooperation with the Army watch officer.

3. Keep the Army watch officer continually informed on developments of any situation embracing:

a. Enemy action.
b. Movement of hostile or suspect vessels or aircraft.
c. Movement of Naval vessels and convoys.
d. Anticipated arrivals of vessels likely to be reported by Army OP's.

4. Cover the Army watch officer in any emergency at the request of the officer.

5. Remain at or close by the HECP during his watch, covering the control desk at all times either himself or by adequate officer personnel.

6. Control traffic in and out of the Port of Boston, having due regard for:

a. Security of the port.
b. Security of Gate, net, and gear.
c. Expediting of Naval vessels, convoys and routed ships.

Direct necessary policing of traffic by:

a. Orders to Gate Vessel.
b. Orders to HECP boat based at Gate Vessel.
c. Granting or denial of traffic movement requests by Examination Vessel, Inner Guardship and Coast Guard Sub-Base.
d. Orders to Examiation Vessel and Inner Guardship.
e. Request to Coast Guard Sub-Base or any Naval or Coast Guard Vessel in vicinity.
f. Request to Commander, Boston Section (Lockwood Operations) for patrol craft or boats and subsequent orders to them.
g. Request to Controller (CNG), Captain of Port, Port Director, Captain of the Yard, and FAO (Duty Office) for such help in orders and communications as appears wise and necessary.

7. Request of the Army watch officer such searchlight illumination or curtailment thereof as may be necessary to identify and destroy any hostile craft or to protect friendly shipping.

8. Request of the Army watch officer arming and disarming of mine fields, firing of challenge rounds, and firing for effect by Army fortifications for the destruction of enemy craft, security of the port, and safety of our own and friendly craft.

9. When satisfied as to reasonable security for own and friendly craft, give clearance to the Army watch officer on his requests to arm mine fields or fire from Army fortifications.

10. Report personally by telephone to Controller (CNG), to Commander, Boston Section (Lockwood Operations), and to the Officer-in-Charge, HECP any unusual or extraordinary occurrences or reports.

11. Evaluate with Army watch officer all Loop reports and make immediate emergency reports on any deemed suspicious.

12. Keep the traffic log and supervise teletype reports therefrom.

13. Initial all Naval messages and dispatches sent and received during his watch.

14. Write up and sign the station log for his watch. Entries should show:

a. Any extraordinary occurrence with reference to memo report or dispatch which will make possible easy investigation at a later date.
b. Transfers of personnel.
c. Drills and inspections.
d. Visitors of commander or higher rank.
e. Breakdown or securing of any gear or Loop.
f. Weather at four-hour intervals.
g. Opening and closing of gate and reasons therefor.
h. Statement that teletype, visual and radio logs for his watch have been verified.

15. Telephone FAO (Duty Officer) names of Naval vessels, other than LDF, arriving and departing.

16. Telephone Captain of Yard (Duty Officer) names of Naval vessels, other than LDF, arriving as soon as identified and obtain berthing for them.

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17. Supervise relaying of berthing information to and any other helpful communication with Naval vessel.

18. Telephone Office in Charge, Commonwealth Pier 5, names of any entering vessels scheduled for berthing here.

19. Render all aid possible in furnishing requested information to any Army or Naval unit, having in mind security of confidential and secret information. When sure of identity of other party, telephone communications to Fort Warren, Fort Banks, Lockwood, District via Lockwood, Navy Yard, and direct lines on their switchboards and our own may be considered reasonably secure. Never give any information of any kind to an unidentified party or to anyone on an outside (commercial exchange) line.

20. Supervise Naval officers on Radar and Communication watches and any Naval officers under instructions.

21. Instruct all junior officers at the post insofar as practical with due regard for your own and their duties. Develop junior watch officers by having them stand the control watch under close supervision.

22. Instruct petty officers on your watch and see they in turn instruct nonrated men in their section.

23. Call CPO on duty to the station in any emergency or any situation when doubtful of regular watch's ability to handle it.

24. Control through the CPO on duty the use of any automotive equipment belonging to the post.

25. Exercise command in the absence of the Officer-in-Charge over all Naval personnel at the barracks or elsewhere on Fort Dawes.

26. In absence of Officer in Charge, be responsible for all Navy property at the HECP and the Naval barracks at Fort Dawes.

27. Officer having early morning watch will work out Naval challenges for succeeding 24 hours.

28. Officer having early morning watch will make out daily ETA and ETD sheets for expected traffic, logging originator and date-time group together with any special instructions for each entry.

29. Officer having early morning watch will make rough draft of War Diary for preceding day.

30. Thoroughly post your relief on:

a. Special instructions.

b. Expected movements.

c. Past occurrences to which reference may be made in his or subsequent watches.

d. Condition of all gear.

31. Report ready to relieve 15 minutes before the hour, and never relieve until properly posted.

32. Never leave station until properly relieved.

B. *Assistant Watch Officer's Duties*:

1. Keep posted on Radar operation and be at the instrument during any alert.

2. Assist in every way possible in training of enlisted personnel in operation of Radar. It is not the intention to take over actual manipulation of dials, etc., from the Army Radar operators, but, unless each of these operators is thoroughly indoctrinated and understands the full possibility of useful information, the Navy assistant watch officer should not hesitate to step in.

3. During any alert, keep the watch officer posted on ship movements shown by Radar.

4. Handle all coded and encyphered dispatches except routine traffic control messages.

5. Officer having 1500 to 2300 watch will work up encyphered calls for the Greenwich date, which begins at 2000 Q, of ships and stations ordinarily having traffic with this station; also set up the HAG machine.

6. Keep the card index of secret and confidential publications up to date, and be responsible for their proper stowage.

7. Make corrections to call sign books and secret and confidential publications.

8. Keep Officer in Charge informed of change in status of any secret and confidential publications.

9. Assist all enlisted personnel in studies for advancement.

10. As assistant watch officer, take over watch officer's duties at his request.

11. Supervise the observers in listing and maintenance of clearance hoists.

12. Report ready to relieve 15 minutes before the hour and never relieve until properly posted.

13. Thoroughly post your relief on:

a. Special instructions.

b. Expected events.

c. Past occurrences to which reference may be made in his or subsequent watches.

d. Condition of all gear.

14. Never leave station until properly relieved and granted permission by watch officer.

15. Report immediately to watch officer any breakdown of equipment or delay in communications.

C. *War Diary*:

1. War Diary will be worked up on rough draft form for preceding day by watch officers having the watch ending at 0700, signed and left as part of traffic log on yeoman's desk.

2. First paragraph of daily War Diary will be analysis of traffic logged in and out of Port of Boston at HECP.

3. Second paragraph will be details of enemy or suspected enemy activity and action taken or orders issued by HECP, chronologically arranged.

4. Third paragraph will be interesting or unusual events, including opening and closing of port or gates at abnormal times, violations of port regulations, etc., chronologically arranged.

5. War Diary items are to be brief but explicit. They will be read by persons unfamiliar with peculiarities of the port, this post and our terminology. Never use code words in them.

D. *Recognition Signals*:

1. The 2300 to 0700 watch officer is strictly accountable for the 7M recognition signals being correctly listed in prescribed form to show both GMT and local times and dates.

2. He may have the communications officer draw off the signals, but must personally verify them.

3. The watch officer is not relieved from this responsibility when he turns over the watch; every succeeding watch officer has the right to depend on his work, and check-up may be impossible.

E. *Traffic Log*:

1. The traffic log will be kept by the watch officer and not delegated except as he may be relieved by the assistant watch officer or a junior watch officer under instruction.

2. Supporting Quartermaster log or notes may be kept by either or both observers as watch officer may direct for the purpose of checking times, names, etc.

3. Traffic log will be handled as closely as practical in accordance with following routine:

a. As soon as an inbound Naval vessel is sighted or reported by the Examination Vessel, enter her type in appropriate column, and time and by whom just sighted.

b. As soon as an inbound Naval vessel is identified, enter call and name in appropriate column.

c. As soon as an inbound merchant vessel is reported by Examination Vessel and given permission to enter the port, enter her name, and type, and time of report by Examination Vessel as time sighted.

d. As soon as any outbound Naval vessel is reported by Pier 4 or Inner Guardship, enter her call name, and type, and time of that report as time sighted.

e. As soon as an outbound merchant vessel is reported by Inner Guardship and given permission to leave, enter her hoist, name and type, and time of report as time sighted.

f. As soon as any vessel passes through gate, enter destination if possible or direction and time. If vessel is moving in or out of Narrows or Nubble to or from North Channel, enter time of such movement with appropriate notation.

g. Do not log Disturbance or vessels working on gate each time they run in or out.

h. Use observers more and bridge less for traffic log data.

i. Keep the Army watch officer informed of entries and get advance information from him of expected entries.

4. The traffic log must show at any given moment, the exact condition of traffic moving in and out of the port. Keep it up to the minute.

F. *Arrival and Departure Logs*:

1. Watch officer will keep log of expected arrivals and departures of all vessels on which information can be obtained, except merchantmen carrying identification hoists and small boats given Affirm permits by Captain of the Port of Boston. He will enter this information on "Expected" lists as soon as received and log times as soon as these vessels move in or out.

Chapter XX

Ship's Regulations

Watch List:

The four-watch section will stand six-hour watches in accordance with following watch list, work sheet. This list is based on a four-week period and then repeats. It automatically takes care of extra length week-end liberties. With the work party inserted as a watch, it will be noted that the watches run serially across from day to day except for Mondays when work party and mid-watch are switched to provide a long week-end liberty. After listing sections, scratch the work party for Sundays and holidays. Saturday work party may be for nominal work or excused.

December Date	Day	0000 to 0600 mid	All day work		0600 to 1200 morning	1200 to 1800 afternoon	1800 to 2400 evening
1	Sunday	1	2		3	4	1
2	Monday	3	2		4	1	2
3	Tuesday	3	4		1	2	3
4	Wednesday	4	1		2	3	4
5	Thursday	1	2		3	4	1
6	Friday	2	3		4	1	2
7	Saturday	3	4		1	2	3
8	Sunday	4	1		2	3	4
9	Monday	2	1		3	4	1
10	Tuesday	2	3		4	1	2
11	Wednesday	3	4		1	2	3
12	Thursday	4	1		2	3	4
13	Friday	1	2		3	4	1
14	Saturday	2	3		4	1	2
15	Sunday	3	4		1	2	3
16	Monday	1	4	(4	2	3	4
17	Tuesday	1	2	weeks'	3	4	1
18	Wednesday	2	3	period)	4	1	2
19	Thursday	3	4		1	2	3
20	Friday	4	1		2	3	4
21	Saturday	1	2		3	4	1
22	Sunday	2	3		4	1	2
23	Monday	4	3		1	2	3
24	Tuesday	4	1		2	3	4
25	Wednesday	1	2		3	4	1
26	Thursday	2	3		4	1	2
27	Friday	3	4		1	2	3
28	Saturday	4	1		2	3	4
29	Sunday	1	2		3	4	1
30	Monday	3	2		4	1	2
31	Tuesday	3	4	(Start-	1	2	3
	January			ing			
1	Wednesday	4	1	over)	2	3	4
2	Thursday	1	2		3	4	1
3	Friday	2	3		4	1	2
4	Saturday	3	4		1	2	3

Liberty:

1. Liberty will ordinarily be granted to men having the morning watch, as follows:

a. Monday, Tuesday, Wednesday, and Thursday, commencing at 1200 and expiring at 0800 the following morning.

b. Friday, commencing at 1200 and expiring at 2300 Saturday.

c. Saturday, commencing at 1200 and expiring at 0800 Monday.

2. Special short period liberty may be granted by CPO having the duty to men coming off the afternoon watch.

3. The CPO having the duty will be responsible for proper dress of liberty party, mustering in and out; and may deny or curtail for good and sufficient reason which shall be the subject of report to the Officer in Charge.

4. Transportation to and from Naval barracks will be furnished by post's automotive equipment insofar as is practical, giving watch officers' transportation and procurement of supplies priority.

Uniform:

Uniform of day for watch will generally be undress blues.

CPO having duty will prescribe uniform of day, consulting watch officer as necessary. Watch officer may authorize removal of blouses during excessively hot days.

Uniform for work section is dungarees or undress blues.

Uniform for liberty is dress blues except during fine warm weather when CPO having duty may prescribe undress whites for short period liberties.

Head gear need not be worn while under cover at the post but shall be worn on the bridge and outside.

CPO having the duty is responsible for foul weather clothing which he shall issue for watch or work as necessary.

No other dress is allowed except during authorized exercise.

Exercise:

CPO having the duty is responsible for every man not on the binnacle list exercising at least 15 minutes per day.

Exercise may take the form of setting up drills, running, swimming, or organized games.

Senior CPO is responsible for every man receiving at least one hour per week drill under arms until he is fully conversant with the Manual of Arms and marching formations.

Orders for Beach Wagon:

1. Any beach wagon or truck assigned to the post will be driven by a licensed driver delegated to this duty each day by the CPO on duty and preferably drawn from the work section of the day.

2. CPO having the duty is responsible for scheduling of all automotive transportation.

3. Watch officers' transportation shall have first priority; supplies for Navy mess, second; liberty parties, third.

4. Automotive equipment is not intended as exercise-savers by trips up the hill, but may be so used in heavy weather.

5. Gas and oil will be obtained at Section Base, Lockwood Basin, or on authorized credit cards at filling stations.

6. The driver is responsible for sufficient gas and oil being aboard and for general upkeep.

7. Repairs will be made at Section Base on arrangement by CPO having the duty on approval by Officer in Charge.

8. Any accident or breakdown of automotive equipment will be immediately reported by driver and by CPO on duty to watch officer and logged.

Radio Log:

1. Operator's name must be followed by operator's rate.

2. Date must be written on page as follows: Day-Month-Year, e.g., January 26th 1944 is written as 26 January 1944.

3. When standing a split phone watch, the frequency each transmission was heard on must be recorded in parentheses.

4. All personal remarks must be placed in parentheses.

5. Each transmission and each "No Signal" recording must be placed on a separate line except where excessive "No Signal" is expected.

6. Logs must be filed away in proper order. The face of log page one should be faced up and then log page number three should be placed up on top of log page number one. Then log page number five should be placed face up on top of log page number three, etc.

7. No poetic notation on top of radio logs.

8. Radio logs must be kept neat and orderly and above all accurately.

Communications Instructions:

1. Radio watch will guard 1738 kcs., 2150 kcs., 2240 kcs., 2916 kcs., and 3000 kcs.

2. Traffic Control measures will be handled on 2150 kcs. by voice. These messages will ordinarily be in abbreviated form carrying date and time group reference number of the transmitting station. They will be in plain English or in the NLDF code, the usual groups of which will be posted in the Radio Room with visual code equivalent. Short messages will be handled between watch officer's desk and Radio Room over loud speaker system. Long messages or scrambles containing more than one apparently meaningless group will be typed up in Radio Room and delivered, or written out by the watch officer and sent to Radio Room.

3. Messages received will ordinarily be handled on loudspeaker system.

4. All radio messages sent to or from this post or intercepted messages affecting this post will be typed and delivered to watch officer.

5. No message shall be filed until it has been initialed by the watch officer on duty at time it was sent or received.

6. No radio message shall be sent from this post except by authority of the Officer in Charge or the watch officer on duty.

7. Visual messages will ordinarily be handled by flashing light, using as small a light as will prove effective.

8. Visual messages are subject to the same restrictions as radio messages, except that the watch officer may authorize proper visual drill with other shore stations or the gate vessel.

9. All visual messages will be written up by the signal watch. They may be written out for convenience in the visual log, but must be on regular message forms for delivery to watch officer, and for filing.

10. Teletype messages will be filed by Greenwich time.

11. Teletype messages are subject to the same restrictions as radio messages.

12. Radio, visual and teletype logs will be so kept as to afford quick reference.

13. Translations carrying the dispatch date and time group will be filed in safe by assistant watch officer and never with the coded message.

14. All coded messages, except traffic control messages, will be handled by assistant watch officer, or in his absence by an Army or Navy officer, in the secure room.

15. Memos of important telephone calls will be written up and filed as messages.

16. Messages relayed for various Army or Navy offices will always show the correct originators.

Observation Watch:

1. One observer will act as recorder. This duty is to be taken in turn and not for more than two hours at a stretch.

2. The other observer or observers will act as lookouts.

3. The recorder will enter on cards or lists all clearance hoist and Affirm permit data from teletype messages. He will identify vessels from these lists as necessary for the watch officer to grant permission to leave or enter and to make log entries. He will scratch daily X-ray hoists from list as vessels leave and keep the list neat and legible. He will keep a Quartermasters log or notes so as to assist the watch officer in proper logging of times, names, etc.

4. Lookouts will man telescopes or binoculars and keep sharp watch on traffic. Advise watch officer (or recorder, if he is busy) of time through gate of each vessel. Identify all traffic and report same. Use telephone to bridge or gate vessel when essential to make positive identification.

5. Watch officer will use four-man bridge and two-man observation or three men on each as traffic and signaling require.

Watch Standing:

1. Watches are duty, not opportunities for consumption of food, beverage or light literature.

2. Pop bottles will not appear outside of conference room or galley. Coffee and food may be consumed there or in galley when essential.

3. The only exceptions will be for watch officers who cannot leave their posts at meal hours and the night signal watches who may have hot coffee in the Bridge shelter. Coffee is not to be taken to bridge shelter in open cups; leave no dirty cups for next watch.

4. Watches have been arranged to provide reasonable time for regular meals, sleep, recreation and social activity. There is no excuse for running any of these pursuits of happiness in on watch hours. This does not mean the watch officers will allow any man to die of thirst for lack of a bottle of pop, but it does mean laxity on watch will not be tolerated. Get permission from the watch officer to leave your post momentarily and don't overdo it.

5. The smoking lamp is lit everywhere on the past except the open bridge at night. Take care in disposing of butts and ashes so no curtailment will be necessary. Magazines, newspapers, novels, etc. have no place on watch. Occasionally slow watches offer short study periods.

Battle Alert:

Whenever Battle Alert is called at Fort Dawes, Naval personnel of HECP will carry out following instructions:

1. Standby watch (watch having next duty) will report in conference room at the post in charge of CPO having the duty.

2. All men not on watch or in standby watch will assemble under arms at the Naval barracks in charge of Senior Petty Officer present.

3. As soon as men are mustered at barracks, the Petty Officer in charge will personally report to Army defense commander or his aide at headquarters in general conformance to following formula: "Radioman Dota reporting for orders, Sir. I have eight men standiing by under arms at the Naval barracks."

4. During a Battle Alert, watch will be relieved as usual. Officer-in-Charge, or in his absence the watch officer, will then decide on disposition of relieved watch, formation of new standby watch, relief of armed party, etc. No movement of men nor relief other than regular relief of watch will be made until that decision.

Advancement in Ratings:

1. As fast as men can qualify by study, work, conduct, and length of service, they will be recommended for advancement.

2. The study qualifications, for ratings above S1c will be determined by progress examinations. These will be arranged for on application to the Education Officer. School marks and recommendations are the only acceptance substitutes for progress examinations.

3. The work and conduct qualifications will be based on marks given by the watch officers and the CPO's.

4. Length of service in any rating before eligibility for promotion is determined by Bureau of Naval Personnel.

5. Recommendation for advancement by itself will not promote anyone. While the Commander, Boston Section, has the authority in certain cases to rate without final examination where vacancies in the complement exist, it is expected that every candidate will pass the regular examination before promotion is granted.

6. Recommendation for advancement and passing of examination does not guarantee immediate promoton. Vacanies on the post itself may be so filled immediately, but if vacancies for the rating involved do not exist the successful candidate may have to await transfer to an activity having the necessary vacancy.

ANNEX C

INSTRUCTIONS TO HECP WATCH OFFICERS FOR TRAFFIC CONTROL PORT OF BOSTON

1. General

Because of (1) one way gate at Deer Island, (2) junction of North, South, Narrows and Nubble Channels directly in front of gate, (3) bad channel turns in the gate approaches, (4) frequently crowded anchorage in President Roads, (5) 2½ to 3 knot tidal current in the gate, (6) cable areas on both sides of the gate, (7) number of ships loaded with ammunition or gasoline, and (8) lack of standby room on either side of the gate, rigid control of traffic in and out of the port must be centralized at HECP. From his vantage point, with the assistance of alert observers and complete bridge reports of up-harbor conditions, the watch officer is in the best possible position to exercise the necessary control. Knowledge of maneuverability of various types of ships under varying conditions of load, tide and wind is essential for safe operation. The average time to train a watch officer so that he can

handle this situation under stress of heavy traffic, with safety and minimum delay for shipping, is three months. Traffic during the month of March 1944 totalled 5627 logged passages in and out of the port. A heavy day will see 250 passengers with a large portion crammed into a few hours.

2. Outbound naval traffic

(*a*) Advance information is to be considered accurate only when obtained from Surface Controller as a numbered item for his summary sheet of expected movements. It will come from several sources:—Assistant Captain of Navy Yard, Joint Operations Briefing Officer, District Operations Officer, DIO Lockwood, Operations Lockwood, NSLP, Army Water Transportation Officer, Port Director, Coast Guard District Operations, Captain of Port, Navy Yard Waterfront Office, RMO, Vessels Readiness Unit Pier 1, Precommissioning Detail, et al. Whenever any information does not tie in with itemized advices of Surface Controller check throughly with him. Enter itemized information from Surface Controller on Expected Movement Sheet (annex "E"; also post all additions and corrections on it exactly as received so that it may be checked back at any time.

(*b*) Reports on movements should come from Assistant Captain of Yard's office or waterfront office when vessels leave their docks. Pier 4 can be counted on to report as they pass that point. Castle Island Degaussing Station occasionally reports and will whenever requested. With fair visibility bridge should pick them up before they reach Spectacle Island.

(*c*) Recognition by HECP will be made from Bridge by flashing light exchange of calls. This exchange is equivalent to permission for any scheduled Naval vessel to depart and notice to her that favorable gate signals will be displayed as soon as traffic conditions permit. Occasional formal requests for permission to depart may be expected. If gate signals are for outbound and can be held so for the vessel, the answer is a simple "Affirmative." If not, answer is "Affirmative with gate signal." Entry is made on traffic log by watch officer as soon as Bridge reports.

(*d*) Right of way will be given over everything except inbound Naval ships and scheduled convoy movements, but due regard must be observed for safety of all shipping and of gear. A ten minute wait even for a flag is better than a sunk merchantman in the channel or a section of gate torn out. Things may look different to impatient officers on a ship but the HECP watch officer is in the best position to judge safety of vessels on two sides of the gate and of the gate itself. He alone must make the decision on right of way. In order to move major war vessels on scheduled time traffic is regulated as necessary. If advance information indicates conflicting schedules of inbound and outbound movements or convoys, effort should be made to have Surface Controller straighten matters out by change of schedules. Action necessary to insure clear channels and prevent delay at gate for an outbound major war vessel will depend entirely on traffic conditions an hour ahead of scheduled time, and size, speed and maneuverability of vessel concerned. It is usually not essential to close the port for such a movement; although watch officer would not hesitate to do so if traffic threatens to get out of hand. No permission for slow moving traffic like tugs with tows to move with the tide should be given either the Examination Vessel or Inner Guardship within one hour of the ETD of a major warship or task force; and no such permission to move against the tide, within ninety minutes. Traffic from Nut Island to Deer Island Gate or to North Channel should be shut off an hour before the ETD by sending coded message to Nut Island Gate Vessel "Halt Deer Island". Ordinarily traffic can thereafter be controlled satisfactorily by sending the Examination Vessel the code work or group for "Hold inbound traffic; clear channel for outbound movement" a half hour before the ETD. Sometimes it is necessary to choke off an impending rush of outbound traffic which might interfere by sending the Inner Guardship the code word or group meaning "Port is closed except to Naval vessels and special permits", but usually it suffices to give requests for permission to leave the usual delay message. Remember to clear all instructions which hold or delay traffic by sending "Port Open" dispatch when movement has passed out gate.

(*e*) Estimate of delay should be given in a brief but informative visual message to any Naval vessel where such signal will be helpful in handling her. "Delay for inbound" should be sufficient when inbound traffic can be seen from the vessel's position. "Delay of approximately......minutes for inbound" is more helpful when traffic is moving in North Channel and not visible to the delayed vessel.

(*f*) Movements against gate signals are to be generally avoided and only made on specific signal from HECP. While there are many occasions when plenty of room is apparent for a vessel to move against gate signals before the opposing traffic moves into the gate, such action produces three bad effects:—1) Confusion for the traffic moving with favorable gate signal; 2) Other traffic, for which there is not safe time, following blindly against gate signal; 3) Generation of the idea that the gate can be crowded any time to force special permission. If necessary in an emergency the HECP watch officer may signal "Proceed against gate signal". Occasionally to save a small important vessel much time, he may signal her "When nothing in or near gate, proceed against signals." Whenever such orders are issued, the gate vessel must be immediately informed.

(*g*) Logging of time out gate is done by watch officer on the traffic log and on the expected movement sheet.

(*h*) Report of passage through gate is made by telephone to Surface Controller by watch officer as soon as possible and appropriate column on the expected movement sheet checked. In phoning Surface Controller use his item number rather than names. Task Forces with one item number are reported with time of last ship. "Restricted" teletype reports will be made from traffic log entries by teletype operator as follows: Major war vessels larger than Destroyer and all Naval Task Forces except sweeps to CNG only and showing simply item number and time out gate (put an "O" against recorded time of these entries in traffic log so teletype operator will not report by name); Destroyers and small war vessels (unless in task force other than sweeps) by (1) name, (2) number or call, (3) type, and (4) time out gate or from Narrows to North Channel, to CNG and if Coast Guard vessels also to DCGO and COTP. Telephone reports are also to be made to Fleet Administrative Office of all Naval vessels exclusive of local district craft. These reports should be grouped together, so long as none is delayed more than one hour, and phoned by assistant watch officer from expected movement sheet with check in appropriate column. Never give any information regarding departure of a major war vessel over a phone connected through a commercial exchange nor to an unauthorized person. If in doubt about any one representing himself to be a responsible officer, say you will call him right back; the call back over Navy Yard dial switchboard or any command line is sufficient check. Coast Guard and CNG switchboard lines are command lines and considered secure; Lockwood and Fort Banks are not.

3. Outbound convoys

(*a*) Advance information is furnished by Port Director's

Berthing and Anchorage Officer about 24 hours before departure. This comes over command line; he gives time of 1st vessel at gate (not of escorts) and time interval (usually 4 minutes) between ships, then calls off harbor numbers against which watch officer calls back the vessels name from current harbor number board. Even though included in this way for a definite gate time there usually are some vessels which Port Director specifies as going out gate early to calibrate or adjust and join from Examination Area or as arriving late and joining at Exam Vessel or Lightship. All this data is entered on special convoy sheet, headed:

"SECRET CONVOY (Date of departure)

Starts at__________Q __________minute intervals.

No. *Name* *Call* *Time out* *Remarks*"

This job should be done by O-in-C or a watch officer thoroughly familiar with handling of convoys. As soon as convoy sheet is thus made up, phone Surface Controller for names of escorts and straggler coverage and list them with ETD of escorts and calls at bottom of sheet. Note that this sheet takes place of individual entries on expected movement sheet, although the convoy may be listed as one item by Surface Controller. Note also that any ETD given by Surface Controller (except for escorts) will be time of last ship at gate.

(*b*) Reports on movements from docks and anchorages are received only from bridge. If any vessel fails to show within 15 minutes of her scheduled time, inquiry should be made of Port Director's officer stationed at Deer Island Gate Vessel or of his Berthing and Anchorage officer at District. Reports of movement by vessels calibrating or adjusting or arriving late outside will be made by Port Director's officer stationed in Examination Area usually through Examination Vessel for relay by HECP to Berthing and Anchorage officer.

(*c*) Recognition by HECP is made from bridge by reading harbor number pennants. If any vessel in movement lacks such a hoist or has it fouled, watch officer should have bridge signal for call and number and instruct her to fly the latter or clear hoist.

(*d*) Right of way is given over everything. If other scheduled movements offer the slightest chance of conflict, they are to be brought promptly to attention of O-in-C for adjustment with Surface Controller, Port Direcor and others concerned. Once a convoy is underway, it is practically hopeless to stop or delay any of the vessels in it. Only small easily maneuverable vessels should ever be allowed to pass through Deer Island Gate or between Narrows or Nubble and North Channel during a convoy movement. HECP boat should be constantly alert and watch officer should not hesitate to call on Coast Guard Sub-Base for picket boat or on Port Director's officer stationed at Deer Island Gate Vessel for his boat to do necessary police duty. Intraport traffic should be permitted only via Moonhead Gate. Keep Coast Guard Sub-Base and Deer Island Gate Vessel informed of status of traffic control and any unusual developments. The following routine has been found successful over a period of two years and will be followed as far as practical:

I. Consider escorts as an independent movement which may move in midst of convoy. If so these vessels can take care of themselves fitting in between convoy ships as best they can. If they move before the scheduled time of first convoy ship, treat them as any other outbound Naval Task Force. If they move out after the convoy, expedite as high priority outbound task force.

II. Ninety minutes before ETD of first convoy ship on an ebb tide or slack water before an ebb tide, send dispatch to Examination Vessel "No more requests for slow moving traffic". Ninety minutes before ETD of first convoy ship on a flood tide or slack water before a flood tide, send dispatch to Inner Guardship and to Nut Island Gate Vessel "No more requests for slow moving traffic via Deer Island or North Channel". Phone Nantasket SS Line to use Moonhead Gate only until further notice.

III. One hour before ETD of first convoy ship on an ebb tide or slack water before an ebb tide, send dispatch to Examination Vessel "Hold all except vessels directly concerned with convoy movement"; also dispatch to Nut Island Gate Vessel and Inner Guardship "No more requests for slow moving traffic via Deer Island or North Channel." One hour before ETD of first convoy ship on a flood tide or slack water before a flood tide, send dispatch to Inner Guardship and Nut Island Gate Vessel "Hold all except vessels directly concerned with convoy movement"; also dispatch to Examination Vessel "No more requests for slow moving traffic." As soon as dispatch to Inner Guardship and Nut Island Gate Vessel has been receipted for, send them dispatch "Pass Army, Navy, Coast Guard and special permits via Moonhead only." Request Army watch officer to route Army and USMS traffic via Moonhead.

IV. Thirty minutes before ETD of first convoy ship on a flood tide or slack water before a flood tide, send dispatch to Examination Vessel "Hold all except vessels directly concerned with convoy movement." Thirty minutes before ETD of first convoy ship on an ebb tide or slack water before an ebb tide, send dispatch to Inner Guardship, "Hold all except vessels directly concerned with convoy movement. Moonhead gate open."

V. Thirty minutes before ETD of first convoy ship, send restricted teletype dispatch to CNG, CNLDF, Combosec, NY Bos, PD Bos, DCGO and COTP "Port closed for outbound movement."

VI. If any straggler will apparently not reach gate for 30 minutes after rest of movement, consult Port Director's Berthing and Anchorage Officer regarding possibility of re-opening port and letting stragglers be handled as expeditiously as possible under open port conditions.

VII. Immediately after last ship of convoy has cleared North Channel Buoy 10 or as soon as Port Director authorizes opening port despite expected stragglers, send dispatch to Examination Vessel, Inner Guardship, Nut Island Gate Vessel and any vessel on duty policing traffic "Port open"; also restricted teletype dispatch to CNG, CNLDF, Combosec, NY Bos, PD Bos, DCGO and COTP "Port open to normal traffic." Phone Nantasket SS Line Deer Island Gate is clear for them.

(*e*) Estimate of delay should be given in a brief but informative visual message to any Naval vessel held up by the convoy; also on request to Navy, CG or Army officials, Inner Guardship, USMS, Nantasket SS Line and Boston Tow Boat Co. In estimating add one minute to scheduled time interval at gate and multiply by number of ships still to go out unless there is known delay for stragglers.

(*f*) Movements against gate signals have to be made by Coast Guard and other boats (such as Boston Line and Service) handling pilots and papers for Port Director and by tugs concerned with the convoy. Gate Vessel and policing boats should be instructed to pass such vessels through gate against signals when nothing is in or close to gate. Unless an unusually long interval (15 minutes or more) is apparent between convoy ships at the gate, all other vessels should be sent via Moonhead or held up well clear of channels.

(*g*) Logging of time out gate is done by watch officer on

RESTRICTED

convoy sheet and traffic log (with "O" against each time to avoid teletype report of individual ships).

(*h*) Report of passage through gate is made by telephone to Port Director's Berthing and Anchorage Officer of each convoy ship, but calls may be made so as to give times of three or four ships at once. Time of last convoy ship is reported by restricted teletype dispatch to CNG: if movement has Surface Controller item number, dispatch simply gives time for that item, otherwise "Movement completed" and time.

(*i*) Report of time of last convoy ship leaving Examination or Calibration Area is made by Port Director's Officer in boat out there usually through Examination Vessel by number code dispatch to be relayed on telephone from HECP to Berthing and Anchorage Officer. This time is used by Surface Controller for his report by dispatch of departure, and Port Director should inform him, but sometimes he inquires of HECP and care must be used not to confuse this time with time of last ship out gate.

(*j*) Straggler coverage is supplied by CNSLP, not by regular escorts. Vessel assigned takes orders from Port Director, almost invariably relayed by telephone through HECP. This vessel may lie at mooring just outside or inside gate or cover convoy ships adjusting or calibrating outside. She is occasionally forgotten by Port Director when there are no stragglers so must be kept in mind by HECP watch officer.

(*k*) Report to Coast Guard by telephone is necessary; as individual convoy ships are not reported on teletype. After last vessel has departed the port, assistant watch officer phones Captain of the Ports' Anchorage Office reading from Convoy Sheet harbor numbers (not names) and time out gate. Be sure to call attention to any vessel which went out previous day or joined outside, because such vessels are not reported on teletype when passing out gate or joining outside.

4. Outbound Merchant traffic (not in convoy)

(*a*) *Classes:*—

I. Vessels cleared by COTP Boston for specific voyages carry three flag hoists beginning with X-ray and expiring within 24 hours. These are known as daily hoists. Information from COTP teletype dispatch covering hoist, name, nationality, type, tonnage, destination and ETD is entered by Observer on daily hoist list.

II. Vessels cleared by COTP's at this and other ports for regular coastwise runs carry three flag hoists beginning with the flag designating the port where issued (Item at Philadelphia; Uncle at New York, X-ray at Boston, Zebra at Norfolk, etc.) and expiring in 30 days. These are known as 30-day hoists. Information from COTP letter or dispatch covering hoist, name, nationality, type and tonnage is entered by observer on cards arranged alphabetically by flag hoists.

III. Vessels cleared by COTP Boston for operation in local waters carry three flag hoists beginning with X-ray and expiring at end of calendar year. These are known as permanent hoists. Information from COTP dispatch or letter covering hoist, name, nationality, type, and tonnage is entered by observer on list of Permanent Hoist.

IV. Vessels in port less than 24 hours for refuge or other reason not requiring Coast Guard Clearance will carry Port Director harbor number hoist or other identification vouched for by Port Director or COTP.

(*b*) Advance information of departure of Class I vessels is an EDT in the original COTP dispatch, but this is approximate only and frequently wrong by several hours. No advance information can be expected on any Class II or III vessels. Full information is to be expected on Class IV vessels' departure at same time as permission is given them to leave without clearance formalities.

(*c*) Reports on movements come from Inner Guardship regarding vessels outbound through Deer Island or Moonhead Gate, from Nut Island Gate Vessel regarding vessels moving out of Hingham Bay, and from Fort Warren regarding vessels moving out of Narrows or Nubble. HECP Bridge is required to keep a sharp look-out and report to watch officer all vessels moving down harbor. Frequent calls to bridge as to status of outbound traffic are necessary during rush periods.

(*d*) Permission to move out of Boston inner harbor must be obtained by every merchant ship from HECP through Inner Guardship who makes the request by coded radio dispatch stating simply clearance hoist and type of vessel unless going out Moonhead gate when code group for "Moonhead" will be added. HECP Observer checks hoist and type on reference cards or lists and reports name of vessel to watch officer. If vessel appears in files as properly cleared by Coast Guard, watch officer will grant permission to proceed out by sending dispatch reply to Inner Guardship. If vessel can be given favorable gate signals without a delay which would affect smooth flow of traffic or safety of any vessel, the reply to Inner Guardship is a simple "Affirmative." Inner Guardship will then instruct the vessel to proceed out when gate signals are favorable. If delay is necessary, reply will be code group meaning "Permission will be granted but delay is necessary; ask again in ________ minutes" followed by numerals indicating the estimated number of minutes of delay. Such delaying message will be promptly relayed to the vessel concerned by Inner Guardship with instructions to return there to make request again or to standby in President Roads clear of gate entrance and channel until given specific permission to depart. Vessels electing to delay in President Roads may make request at end of estimated time by flashing light signal direct to HECP or by contacting Coast Guard Sub-Base for telephone relay to HECP. If conditions permit sending the vessel out before this request or developments will require further delay, HECP will flash, or transmit by picket boat from Sub-Base, full instructions. Inner Guardship must carefully instruct any vessel proceeding to standby in President Roads that they may not go out until given specific permission regardless of how gate signals may be set or of any other traffic.

(*e*) Permission to move out of Hingham Bay is granted by Nut Island Gate Vessel.

(*f*) Permission to move out North Channel from the Narrows or Nubble is included in Permission granted by Nut Island Gate Vessel, or handled direct by HECP by flashing light or through patrol boat.

(*g*) Right of way will ordinarily be given inbound traffic and outbound traffic should keep out of the way. The watch officer must, however, take into consideration conditions of wind, tide, size of ship and maneuverability in changing gate signals.

(*h*) Recognition will be by reading the flag hoists from HECP and by check wiith Gate Vessels' reports.

(*i*) Destination of Class II vessels must be obtained by Gate Vessels and included in their reports to HECP. Watch officer will therefore instruct observer to have Gate Vessel hail and obtain this information from each Class II vessel proceeding out Deer Island Gate unless the information is available from report by some other unit or from direct signal contact.

(*j*) Time through Deer Island Gate or out from Narrows or Nubble is reported by observer and logged in traffic log by watch officer together with destination of every vessel except those operating in local waters or proceeding to fishing grounds.

(*k*) Report of departure is made in restricted teletype dispatch from traffic log entries to CNG and COTP Boston (DIO and PD Bos automatically cut in on circuit) giving 1) Name, 2) Number or Call, 3) Type, 4) "OUT" or "OUT from Nar-

rows" or "OUT from Nubble", 5) Destination if logged, and 6) Time. These reports are made by teletype operator and may be bunched to cut down volume of dispatches but should not be delayed more than 30 minutes. Operator checks log entry at time he takes data for dispatch, and it is further checked by watch officer from copy of completed dispatch before initialing for filing.

5. Outbound small craft

(*a*) *Classes.—*

I. Army, Navy, Coast Guard, USMS and USPHS.

II. Vessels holding AA permits from COTP. These permits authorize operation in all local waters for official business and are issued to city boats, experimental craft, etc. They are good until revoked. Information identifying each vessel and its operations is furnished by COTP letter or dispatch to HECP, Nut Island and Moonhead Gate Vessels, Inner Guardship, and Sub-Base.

III. Vessels holding A Permits from COTP. These permits authorize operation in specific local waters and are issued to lobstermen, work boats, etc. They are good until the end of the calendar year. Information identifying each vessel, and the areas in which it is allowed to operate is furnished by COTP letter to HECP, Nut Island and Moonhead Gate Vessels, Inner Guardship, and Sub-Base.

IV. Vessels holding B permits from COTP. These permits authorize passage to and from specified ports. Because movement of small craft is so dependent on weather, no time limit may be fixed but the permit is strictly limited to the one trip and return.

V. Pleasure boats which are licensed by COTP for operation in one or more of the following areas:— Area A (Winthrop Bay), Area B (Dorchester Bay), Area C (Quincy Bay), and Area D (Hingham Bay).

(*b*) Advance information of movements from docks and anchorages is not available.

(*c*) Reports of movements are only received at HECP when Inner Guardship or Sub-Base request permission for vessel to go through Deer Island or Moonhead Gates or when Nut Island Gate Vessel reports a vessel leaving the port.

(*d*) Permission to go out Deer Island Gate: During normal port open hours specific permission from HECP is not required for Class I boats but is required for any others. Class I boats if equipped with signal light or radio often contact HECP direct for permission in order to avoid delays. Class II boats may make requests through Inner Guardship or Sub-Base. Class III and IV boats make requests through Sub-Base. Class V boats are not permitted out this gate. Whenever gate or port is closed, special permission must be obtained from HECP for passage by boats of any class.

(*e*) Permission to go out Moonhead Gate: During normal port open hours specific permission is not required by Class I, II and V boats. Class III boats must obtain permission from Inner Guardship, but these requests need not be referred to HECP. Class IV boats are not permitted out this gate. Whenever gate or port is closed, special permission must be obtained from HECP for passage by boats of any class.

(*f*) Permission to go out Nut Island Gate: During normal port open hours, specific permission is not required by boats of any class. Whenever gate or port is closed, special permission must be obtained from HECP for passage by boats of any class.

(*g*) Delayed permission: Vessels intending to use Deer Island Gate may be given an estimated delay with promise of later permission by HECP through Inner Guardship or Sub-Base in same way as for large merchantmen. Inner Guardship, Sub-Base, or Gate Vessels may ask HECP for estimate of delay for other movements such as via Moonhead Gate, when port is closed for any reason.

(*h*) Right of way is given Class I and II boats as far as is practical considering seniority and mission assigned. Class III, IV, and V boats are given no special consideration.

(*i*) Recognition is by Inner Guardship, Sub-Base or Gate Vessels.

(*j*) Logging of gate passages is made by Gate Vessels in all instances, and by HECP for passages of Deer Island Gate as reported by that Gate Vessel.

(*k*) Report of passage is made on teletype only in case of Coast Guard boats to COTP and CG Harbor Patrol Operations and of Class II and IV boats to CNG and COTP. In both these cases passage is through Deer Island Gate or to sea.

6. Outbound Government vessels other than naval

(*a*) Coast Guard vessels are handled in same way as Naval vessels except that CG boats out Deer Island Gate are reported on teletype regardless of size.

(*b*) Coast and Geodetic Survey vessels are handled in same way as Naval vessels.

(*c*) Army vessels are handled same as Naval vessels except that they are reported only if leaving port.

(*d*) Maritime Service and other governmental craft not otherwise mentioned will be handled as nearly like Naval craft as reasonably possible but are subject to all restrictions applied to merchant vessels when necessary to control any situation. They are reported only if leaving port.

7. In-bound naval traffic

(*a*) Advance information may come from Assistant Captain of Yard's office, Fleet Administrative office, Port Director's office, Waterfront office, DIO Bulletin, any office at Lockwood or Pier One, Army G–2 office, Sandwich HECP, or Scuttlebut. Any and all such information is to be accepted without comment as news; but none of it is to be accepted as final and authentic until confirmed as an official item from Surface Controller. Columns are provided on Expected Movement Sheet for preliminary advance information and any which appears probable and has a time factor falling with the scope of the current list from Surface Controller but differs from his should be brought to his attention for checking. Preliminary advance information is corrected on expected movement sheet by erasure and change as more probable or corrected information is received; but changes in Surface Controller items are to be made by reentry and drawing line through previous entry. These items are given at 0600 and 2000 daily in accordance with Annex D and corrected by telephone from Surface Controller as soon as he has notice of any change. Surface Controller furnishes name of last ports of call and clearance in order to help determine quarantine requirements.

(*b*) Reports of movements are occasionally received from Surface Controller on receipt by him of position reports and HECP watch officer should request such information whenever necessary to plan for proper control. Usually the reports received from the Army, Sandwich HECP, Loop stations and Examination Vessel are sufficient to tie in identification with advance information. Sandwich HECP reports to Army watch officer give names, but other reporting units give type of vessel only.

(*c*) Challenge by Examination Vessel is required for minor warships and, inasmuch as the challenge to be of use must be made while vessel is far enough away to make it impossible to determine whether she is a major or minor war vessel, is usually made to any inbound warship sighted. Examination Vessel uses shore to ship challenge which may be confusing to strangers

and major warships are not required to answer her challenge; so she will not attempt to stop or open fire on any entering warship unless ordered to do so by HECP or unless the entering vessel is obviously hostile. When port is closed to all vessels, Examination Vessel will belay efforts to challenge in time to signal preemptory order to entering warship to heave to near her and follow it up with warning shots if necessary. HECP watch officer therefore must be careful as to degree port is closed in instructions to Exam Vessel. Any failure to reply or wrong reply will be immediately reported by Exam Vessel to HECP.

(*d*) Challenge by HECP is required for every entering warship regardless of challenges by Exam Vessel or any other unit. This is necessary because identity cannot be established with security before challenge and exchange of calls. HECP bridge will challenge with short series of INT's as soon as an entering warship is first sighted. If not reply or wrong reply is received, bridge will report to watch officer and further challenging will be on his orders. Correct reply will be acknowledged by bridge by "R" and followed by exchange of calls for identification. If a warship flashes the correct reply to challenge before it has been made, bridge will immediately flash the challenge and expect repeat of the reply. Watch officer may order challenge on a bearing while entering vessel is still not visible to the eye, if distance and visibility present probability of working the vessel by signal searchlight.

(*e*) Identification must be positive before a vessel is allowed to move in from Examination Vessel. Signals and warning shots will be employed from Examination Vessel, HECP and shore batteries as watch officer deems necessary. Any unexpected warship will be cleared by Surface Controller before being allowed to enter.

(*f*) *Alert:* Report from Examination Vessel of failure to reply or of wrong reply to challenge or of any suspicious circumstances should put watch officer at HECP on instant alert for trouble. It is essential that Naval watch officer keep his Army colleague fully informed of every detail of developments in such a situation. Alerting of Examination Battery should be followed immediately by alerting of Gate Vessel. Firing of a warning shot is sufficient reason to alert all units of traffic control. Such action should be immediately reported to Surface Controller, Combosec and Officer in Charge of HECP.

(*g*) *Quarantine:* HECP is charged with responsibility of determining quarantine requirements of Naval vessels and making necessary arrangements for inspection.

Procedure is as follows:

I. Navy Regulation 1452(1) provides that the Commanding Officer of a Naval vessel arriving in port with a quarantinable disease on board shall hoist the quarantine flag. HECP may therefore presume, unless information to the contrary has been received, that any vessel not flying "Queen" is free from known quarantinable disease. Note, however, that absence of known quarantinable disease does not have any bearing on necessity of quarantine inspection or certificate if arriving from a foreign port.

II. Presence on board of quarantinable disease requires that the vessel proceed to quarantine anchorage (President Roads) and remain there flying "Queen" until released by the Quarantine Officer. HECP will so direct the vessel by flashing light signal or by relay through the Examination Vessel or patrol boat. HECP watch officer will phone Quarantine Office giving ETA in quarantine anchorage and request earliest possible inspection.

III. If there is no known quarantinable disease on board and if last port of both clearance and call were in the United States, Canada, Newfoundland, Cuba, the Bahamas, Bermuda or on the Western Coast of Lower California, no quarantine inspection or certificate is necessary. Note that word "both." Bermuda or Argentina as a last port of call mean nothing if vessel cleared from Oran. Surface Controller should have complete information of port of departure and ports of call; but, if he does not have definite advice, HECP must signal the vessel direct or through Examination Vessel or patrol boat and obtain it.

IV. If there is no known quarantinable disease on board and if the last port of clearance or any subsequent port of call was outside the United States, Canada, Newfoundland, the Bahamas, Bermuda and the Western Coast of Lower California, the vessel requires quarantine inspection or a certificate prepared by both the Commanding Officer and a commissioned medical officer attached to the vessel or to a vessel in company.

V. Cruisers, transports and larger vessels may be presumed to have commissioned medical officers on board. HECP will signal any of them falling in the category of paragraph IV with "Comply with general order one five seven". This may be added to their berthing instructions.

VI. Any vessel smaller than a cruiser or transport may or may not have a commissioned medical officer on board. HECP will signal any such vessel which falls in category of paragraph IV "Do you have commissioned medical officer on board?" If reply is affirmative, HECP will signal "Comply with general order one five seven." If reply is negative but vessel is in company with a vessel having a commissioned medical officer on board. HECP will signal the latter "Will your medical officer sign certificate for vessel in company to enter under general order one five seven." If reply is affirmative, HECP will signal the vessel without medical officer, "Comply with general order one five seven obtaining statement from medical officer of accompanying vessel."

VII. Any vessel falling in the category of paragraph IV which is unable to produce a certificate as prescribed by general order 157 must be inspected by Quarantine Officer. Note that this is a different situation from one where quarantinable disease is known to be on board and he is usually agreeable to making the inspection at the dock instead of holding the vessel at Quarantine Anchorage. In this case, HECP watch officer will phone Quarantine Office giving the ship's status and assigned berth with a diplomatic request that inspection be made at the dock. If the Quarantine Officer agrees, HECP watch officer will give him ETA at dock and signal the vessel "Fly Queen and allow no one to leave ship until permission granted by Quarantine Officer who will inspect at dock." If Quarantine Officer declines, HECP watch officer will give him ETA at Quarantine Anchorage and signal the vessel "Fly Queen and remain in President Roads until cleared by Quarantine Officer."

VIII. If contact cannot be made with Quarantine Officer at his office or home, or if unreasonable delay for inspection appears certain, HECP watch officer will request Senior Medical Officer, Navy Yard, Boston, to accomplish required quarantine inspection.

(*h*) Right of way will be given over everything except convoy movements and other priorities specified by Surface Controller. Due consideration, however, must be given to safety of gear and other vessels with regard to tide, wind, manueverability, etc.

(*i*) Gate passage against signals is occasionally necessary for smaller vessels than destroyer but is not good practice and should be confined to emergencies. Tendency of other vessels to follow blindly in lead of vessel sent against signals has produced some bad situations. When necessary, HECP sends flashing light message to vessel "Proceed in against gate signal" or better "When nothing in or near gate, proceed against gate signal,"

and tells gate vessel "Pass ________ against gate signal."

(*j*) Report of approach is made by HECP watch officer by telephone to duty officer of Assistant Captain of Yard as soon as a naval vessel other than Boston Section or NSLP craft is recognized. Berthing instructions are then obtained or previous instructions verified. If Assistant Captain of Yard does not have Berthing Instructions for Coast Guard, call District CG Operations. Boston Section may sometimes handle berthing of landing craft and naval tugs. "Remarks" column of expected movements sheet, clip board, and desk data board must be examined to see if any other office requires notification on sighting. If vessel is to berth at Commonwealth Pier 5, telephone duty officer there or be sure Assistant Captain of Yard is phoning him that she is approaching.

(*k*) Berthing instructions as given to vessels must be specific and so worded as to avoid any misunderstanding or misinterpretation.

Arrange messages as follows:

(I) Geographical location (Charlestown, East Boston, South Boston, etc.).

(II) Name of Yard or Dock (Navy Yard, Annex, Drydock, Commonwealth, etc.).

(III) Number of Pier (Pier one, Pier five, etc.).

(IV) Side of pier (East Side, West Side, etc.).

(V) Detailed Docking Instructions (Starboard Side to, Alongside ________, etc.).

(*l*) Pilots and tugs are always supplied DE's and larger vessels to aid in docking. Vessels requiring harbor pilots usually pick up regular Boston Pilot outside. On demand, Captain of Yard will send pilot and tug outside, but the stock answer to inquiry is "Tug and pilot will meet you up harbor."

(*m*) Logging of time in gate is done by watch officer on traffic log and on expected movement sheet.

(*n*) Report of passage through gate is made by telephone to Surface Controller by watch officer on all except Boston Section craft as soon as possible and appropriate column on expected movement sheet checked. Telephone reports are also made to Fleet Administrative office on all except Boston Section and NSLP craft. These reports should be grouped together so long as none is delayed more than 30 minutes and phoned by assistant watch officer from expected movement sheet with checks in appropriate column. Restricted teletype reports will be made from Traffic Log entries on all vessels except running boats by teletype operator giving 1) name, 2) number or call, 3) type, and 4) time in gate or Narrows. All these teletype reports go to CNG, and to Combosec if basing or berthing at Section Base, to DCGO if Coast Guard, and to COTP if basing or berthing at Coast Guard Base.

(*o*) Messages to and from inbound Naval craft are ordinarily handled by flashing light at HECP after they have made the turn at Finns Ledge. Avoid sending messages while a vessel is beyond Examination Vessel unless they affect her immediate movements or she requests information.

8. In-bound convoys

In-bound convoys almost invariably break up before reaching the approaches to Boston, so vessels are handled individually in accordance with procedure for in-bound merchant traffic. Exceptions are usually troop ships which are given Naval status. Any convoy arriving as a unit is handled as a Navy Task Force, with instructions relayed to SOP and reporting time as of last ship in.

9. In-bound merchant traffic

(*a*) *Advance information.*

I. Routed ships are given harbor numbers by the Port Director as soon as he has advice of their routing to this port. Number name and call of each ship is phoned to HECP and entered in kardex file. If docking or berthing instructions are ready at this time, they are included; otherwise they may be expected at any time before arrival. Every morning the HECP guard mail trip leaving Lockwood Basin at 0945 brings out a copy of Port Director's report of merchant ships present and expected, which the assistant watch officer checks against kardex file, correcting any discrepancies after phone consultation with Port Director's Berthing and Anchorage Officer. At time of entering a vessel in kardex file, dispatch is sent to Examination Vessel and Coast Guard Sub-Base to expect her, giving harbor number, call and berthing instructions if known.

II. Coastwise vessels are usually reported by dispatch from the Captain of the Port of departure. If a vessel is moving to Boston via Cape Cod Canal, this information is disregarded; as the Canal report is sufficient advance information. If not using the Canal, the vessel is picked up on observers list for tracking.

(*b*) *Reports of movements.*

I. Vessels leaving Cape Cod Canal for Boston are reported immediately by Sandwich HECP to Army watch officer and picked up on observers list for tracking. Teletype dispatch from COTP Sandwich also arrives via Coast Guard channels, affording a check on observers list.

II. Important movements such as vessels breaking away from convoys for entry into Boston are reported by Surface Controller.

III. Army OP's and Loop stations report vessels sighted by type and estimated size. No coastal station is close enough to ship lanes, however, to make signal identification possible.

IV. Pilot vessel is allowed to use a radio code advising the pilots' office that any vessel previously assigned a harbor number has been boarded outside. This information is passed to HECP by Port Director during the day or direct by pilots office at night whenever any special consideration is due the vessel.

(*c*) Stop at Examination Vessel is made by every entering merchant vessel and none may proceed beyond the outer Examination Area without permission from HECP. Boarding Officer when satisfied from examination and/or advance information and positive identification sends HECP code message requesting permission. This dispatch gives identifying hoist or name for all except fishermen, yachts and such small craft as present no traffic problem and could easily be handled, in event they proved hostile, by the Gate Vessel.

(*d*) Right of way will ordinarily be accorded inbound vessels, but only with due regard for tide, wind and traffic conditions. HECP watch officer will grant immediate or delayed permission to enter as necessary to control traffic, always bearing in mind that any form of control is bound to delay and it is his duty to keep the shipping moving with safety.

(*e*) Logging of time in Deer Island Gate or into Narrows or Nubble will be done by watch officer on traffic log on every vessel regardless of size.

(*f*) Report of passage through Deer Island Gate or into Narrows or Nubble is made by teletype to CNG and COTP (PD automatically cuts in on circuit) from HECP on every merchant vessel except small boats which are directed by Examination Vessel and Gate Vessels to report to Coast Guard Sub-Base. Telephone report is also made by HECP watch officer to Port Directors' Berthing and Anchorage Officer on any vessel for which berthing instructions have not been previously received, any unusual or important vessel such as an ammunition ship, and any vessel for which report has been requested.

10. In-bound Government vessels other than naval

(*a*) Coast Guard Vessels are handled in same way as Naval

vessels except that teletype reports are made on all vessels regardless of size.

(*b*) Coast and Geodetic Survey vessels are handled in same way as Naval Vessels.

(c) Army vessels are handled same as naval vessels except that they are reported only if entering from another port.

(*d*) Maritime Service and other governmental craft not otherwise mentioned will be handled as nearly like naval crafts as reasonably possible but are subject to all restrictions applied to merchant vessels when necessary to control any situation. They are reported only when entering from another port.

11. Lynn traffic

Lynn traffic will be handled the same as Boston traffic except time to and from Lynn will be taken as time at the Examination vessel and Exam Vessel need not wait for HECP's permission to send vessels into Lynn.

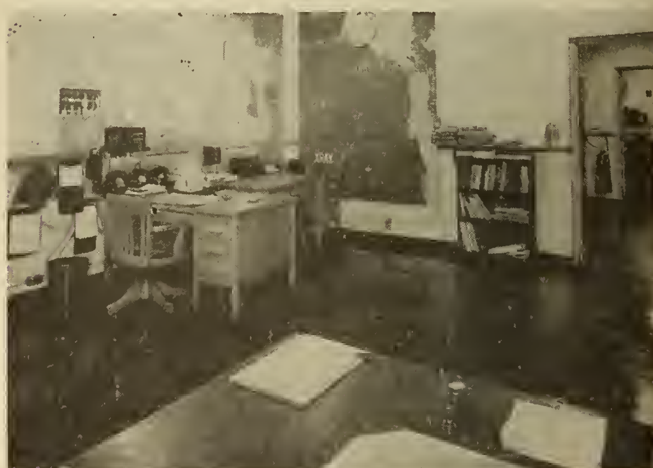
DETECTED BUT NOT DESTROYED . . .

Shortly before midnight during the dark of the moon, a detection operator sat relaxed before his listening equipment at a certain Pacific island base. All was quiet in the narrow harbor approaches and no arrivals or departures were slated for another five hours. Suddenly, the operator leaned forward attentively, adjusted his receiver controls, and then clapped his hands over the earphones on his head, pressing them tightly against his ears. He beckoned to his standby sound operator to "take a listen." The second operator, after listening for a moment, nodded in agreement and called the detection officer.

A large percentage of Harbor Entrance Control Posts in the United States was constructed underground with only a signal tower and flag hoist mast above the ground. The picture here shows the exterior view of the HECP at Fort Winfield Scott, San Francisco, California, which guarded the entrance to San Francisco Bay.

As the officer listened closely, he could discern a very faint "whisper beat" coming in from the seaward-most Sono-Radio-Buoy. Immediately a careful check was made on the next two buoys located in a line along the narrow channel into the harbor. The innermost of these two buoys was anchored deep within the hunting area. No signal was heard on either.

A listening vessel, moored in the channel between the No. 2 and 3 buoys, was contacted through the duty operations officer and requested to perform an echo-ranging and sonic search of the harbor entrance channel. This ship was permanently moored in the harbor approach and was incapable of moving. She reported negative search results. By this time the "whisper beats" were beginning to come in on the No. 2 buoy which was anchored several hundred yards outboard of the listening vessel. The signals were now fairly strong and began to show typical characteristics of the propeller beats of a submerged submarine at slow speed. This information was relayed to the operations officer and through him to the listening vessel. Shortly thereafter the propeller sounds began to come in on the



Telephone communication is an essential element of the Harbor Entrance Control Post because of the number of direct lines that must be maintained between HECP and the various harbor defense components and the other units of the base. This picture shows the telephone switchboard and control room at the HECP, Fort Winfield Scott, San Francisco, California.

The transmitter room at HECP, Fort Winfield Scott, is shown in this picture. HECP personnel should take great care of their transmitting equipment. Without adequate radio transmission, the control of the harbor would be quite a "hit and miss" affair!

The office at HECP, Fort Winfield Scott, is shown here. Both Army and naval personnel worked closely together to guard the important anchorages and shore facilities in San Francisco Bay.

No. 3 buoy anchored in the hunting area. The detection officer again contacted the operations officer and advised that the situation was becoming dangerous and suggested alerting the harbor in spite of the fact that all reports from the listening vessel were still negative.

The operations officer alerted the harbor and ordered the harbor patrol to get underway and conduct an echo-ranging search. Almost immediately after this order was given, the listening vessel, from her position in the channel outboard of Sono-Buoy No. 3 and inboard of Sono-Buoy No. 2, reported a contact with propeller beats being heard.

A quick summary of information gathered so far put the suspected submarine somewhere in the channel outboard of the listening vessel, and approaching the harbor hunting area. In the hunting area were located the No. 3 buoy and several A/S vessels underway.

Detection operators at this particular harbor had become so familiar with the sound and sound reflection characteristics of the hunting area monitored by the No. 3 buoy that they could determine the approximate location of any sound source in that area. As a man with closed eyes seated in a familiar room can mentally trace by sound the movement of another man through that room, so the sound operators were able to trace the approximate movement of the suspected submarine into the hunting area. Just as a well known voice can be distinguished among other voices, so were the sound operators able to maintain contact with the suspected submarine through the noise of the frantically searching patrol vessels.

The suspected submarine apparently became alarmed at all the activity being stirred up in the hunting area for it increased speed, entered the hunting area where it had enough room to execute a 180° turn, and then was tracked out of the place by detection personnel listening to successive Sono-Buoys via the same route it had entered, but at a somewhat higher speed.

Apparently the significance of the outgoing contact reports to the operations officer were lost amid all the confusion since patrol craft were not dispatched to search the harbor entrance for nearly an hour, and by that time chances for contact were greatly reduced.

The patrol craft searching efforts were not controlled from shore, and were controlled poorly, if at all, among themselves. The result was uncoordinated high speed runs all over the hunting area until the place was a bedlam of noise and a confusion of wakes, which gave any number of false contacts officially reported as fish. Some depth charges were dropped with negative results, and finally the alert was called off shortly before noon.

Had an HECP been in control of the situation the results would have been more gratifying.

[redacted]

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The Harbor Entrance Control Post usually maintains a number of radio circuits, depending upon the size of the harbor and its importance. This picture shows the operations room of the HECP at Fort Winfield Scott with radiomen guarding their assigned circuits.

Section IV

SURFACE DETECTION RADAR

Section IV SURFACE DETECTION RADAR

FOREWORD

SURFACE DETECTION RADAR

Wide publicity was given to sea battles during World War II and the strategy and alertness with which U. S. Naval personnel used the many devices on their ships to gain their victory.

After a few general releases were made on same of the more secret weapons, it was not an uncommon thing at all to hear the man on the street discussing them.

"And I understand," they would say, "that our fleet completely licked them without even moving to within sight of one of their ships. They used this new thing called radar. I call it plain remarkable."

"Remarkable" is a word that was attached to radar throughout the war. It supplied far-seeing eyes for the fleets to guard against surface vessels and aircraft. It supplied the same far-seeing results for shore establishments in giving warning to base defenses when enemy craft were on their way to attack. Radar, within a very short time, became one of the most heralded of all war weapons and one on which all personnel, both shipboard and shore-based, relied for warning of an enemy attack.

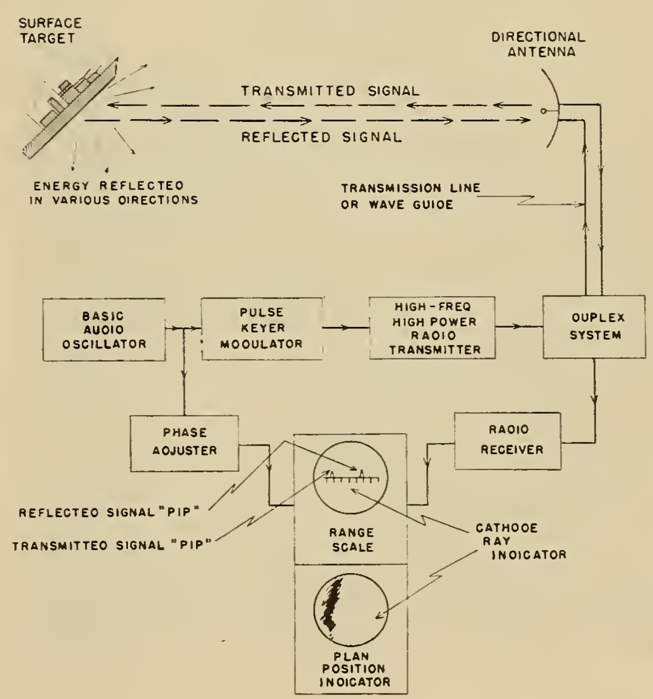
The B7 Surface Detection Radar component in harbor defenses was one of the many radar activities during the war which performed an outstanding job. When the need for such a unit presented itself, the Navy had already made much progress in detecting submerged craft by establishing underwater detection units. But what about the surface craft? An underwater detection component was so designed that it could not adequately distinguish between surface and submerged craft. On misty days with very short-range visibility the Harbor Entrance Control Posts controlling the harbors would find much difficulty in performing their missions. The only sure answer to this problem was radar, a surface detection component attached to harbor defenses and working directly through HECP.

The Navy's program in surface detection radar during the war was one which showed steady progress. The B6 and B7 radar components, organized and trained for this purpose, were attached to Lions, Cubs, Gropacs or other types of base assemblies. All during this time, research engineers were continuing to make progress with the various radar sets. From the SN model used as loop adjuncts at underwater detection stations on through to the SO–12M/N, the most modern of all surface detection sets, the performance and results continued to improve. Performance was so outstanding, in fact, that by the end of the war these SO–12M/N sets were able to detect a saboteur swimmer's head from the areas covering the harbor's entrance.

There are radar models for practically every type of detection, which means that in attempting to cover the entire subject one would find the material mounting into volumes. The B7 radar component during the war, however, was primarily interested in shore-based surface detection—the SG–2S, SO–7M/N and the SO–12M/N.

The articles which are printed in this section about surface detection are minus the technical element except in general terms. For all harbor defense students who wish to study the more detailed fields of the various models, it is recommended that the references in the bibliography be followed. It will be remembered that the SO–12M/N model is far superior to other types discussed, but in order to receive a more complete understanding of the surface detection sets the information printed on subordinate models will prove very helpful.

RADAR



RADAR DIAGRAM

SURFACE DETECTION COMPONENTS

INTRODUCTION

One of the main defenses developed early in the war was in the field of underwater detection where a variety of devices were employed to protect the harbors and approaches to the harbors at advanced bases. As islands nearer the Japanese homeland were taken and secured, the need was felt for the detection of craft on the surface of the water as well as submerged, and plans were made for surface detection by means of organized radar units.

HISTORY

In the spring of 1943 a directive was written by CNO establishing surface detection units and listing the equipments and the personnel required to operate them. At this time, however, radars had not been developed which would satisfactorily answer the needs for the detection units as they were conceived, and plans were made for modified surface detection units, substituting makeshift equipments until more desirable types could be developed and procured. The modified units required SN type radars and were to serve primarily as adjuncts to the underwater detection stations.

As 1943 neared its close, more surface detection units were included in advanced base plans, and by 1944 the desired types of surface search radars were coming off the assembly line. As time passed, experience in actual operations indicated certain changes could improve the units. Additional telephone and radio equipment was added to the allowance list and some revisions were made in the complement.

In the spring of 1945, the B6 components were cancelled and three modernized B7 components were substituted for each B6. The advantage of this was that one Officer in Charge of each coordinated team was supplied for each radar location.

ORGANIZATION

The functions of B6 and B7 surface detection components were to provide warning of and further pertinent information regarding the movements of surface craft and low-flying aircraft. This information was furnished directly by telephone to Harbor Entrance Control Post, Combat Information Centers and/or Command Control Posts at the base to be used in defense of the harbor.

B6 components were large units designed to go out with a Lion or large Advanced Base Assembly. The complement called for one Officer in Charge and 46 enlisted men, including radarmen and radio technicians. The equipment included three fixed surface search radars (FSS) and two mobile surface search radars (MSS).

The B7 component was a small surface detection unit to be included in smaller advanced base assemblies—such as, Cubs, Acorns and Gropacs. One Officer in Charge and 23 enlisted men made up the complement. The major items of equipment were as follows:

1 FSS radar.

1 MSS radar.

Transmitter, Receiver and Transreceiver.

1 Generator set.

6 Circuit communication system and outside electrical distribution.

Automotive equipment.

Housing.

TRAINING

The training program for surface detection components was divided into the following three phases:

The initial training of four weeks duration was carried out at Pt. Loma, San Diego, California. Here the personnel received instruction in the operation of radar equipment, identification of targets, I.F.F. devices, plotting, and communication operation and procedures. The final week of training consisted of unit operation, including the taking of field trips with the mobile surface detection radar, the operation of all equipment and the simulation of actual field conditions.

The second phase of training was carried out at San Pedro Section Base and lasted for 30 days. This course was designed to serve as a final functional training period for Harbor Defense Units. The objectives of the training program were to acquire general knowledge of the organization and administration of advanced bases, the role of surface detection in the organization with its duties and responsibilities, and its relation to all other harbor defense components. The operational nature of this second phase of training demanded that activities carried out should bear a close relationship to the activities actually required under advanced base conditions.

The third phase of training was carried out after the component had reported to the advanced base assembly to which it was assigned. This lasted until the unit shipped out of the United States and consisted largely of tactical training as a part of a large movement.

OPERATION

The B6 and B7 components usually went out with the third echelon of an advanced base movement and were taken ashore shortly after the island objective had been secured. The mobile surface-search radars were set up at pre-determined sites and put in operation after a period of a few hours. All ship movements were plotted and reported to the appropriate command.

During this time, the fixed surface search with its 80-foot tower was being installed, an installation that required several weeks. When it was completed and the set properly tested and adjusted it was put into operation with the mobile surface search set being used as standby. All contacts of surface craft and low-flying planes were plotted and information supplied to Command Posts where necessary defensive action was initiated.

The contribution of these components to the success of the war cannot be measured, as they are defensive units and serve to protect and provide warnings necessary for the safety of our harbors. It might be said that their chief value was that they provided the "ounce of prevention"—preventing the necessity of the "pound of cure."

SURFACE DETECTION RADAR PERFORMS MAJOR ASSIGNMENT

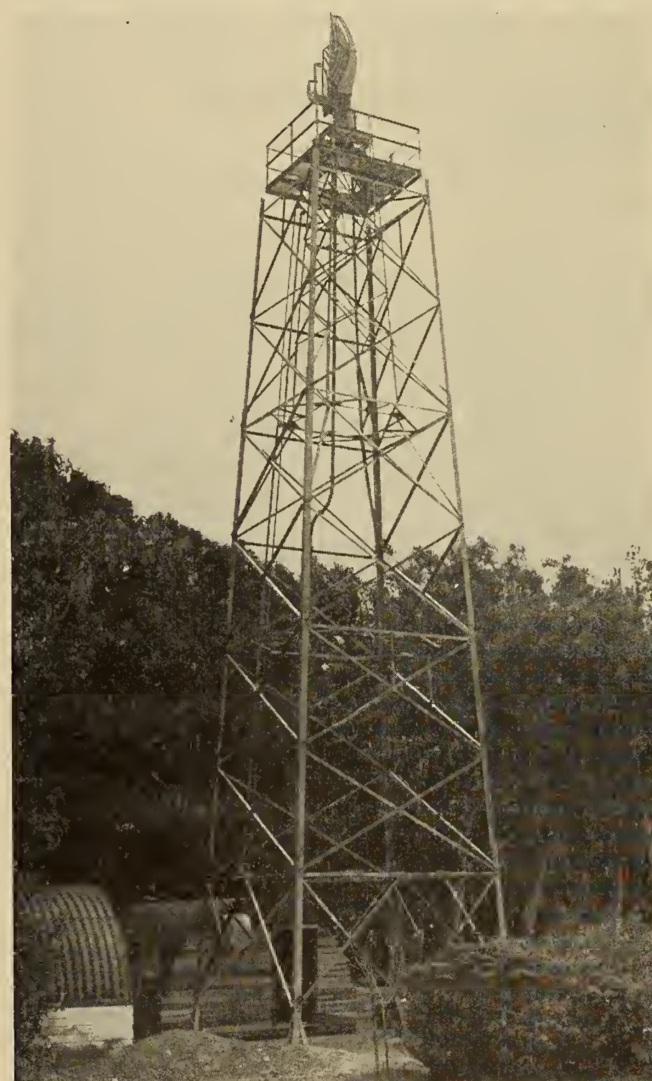
The mission of surface detection radar components in connection with harbor and base defense is to provide warning of any surface craft or low-flying aircraft approaching or attempting to close the base or approaches to a harbor. The size and formation of the area for which coverage is desired will be the determining factor in deciding how many radars will be required.

No matter what the size and formation of the area may be, the function of surface search components is to detect all contacts within radar range, challenge by IFF, and report immediately any contacts to the appropriate interested activities. In the case of surface targets, reports will go to HECP and base operations, and, in the case of unidentified low-flying aircraft, to ADCC and base operations. It is of little value to report surface targets to ADCC unless specifically called for, nor is information on air targets of value to HECP. Speed is essential in reporting unidentified low-flying aircraft which might be trying to make torpedo runs on shipping in a harbor, in order that ADCC can immediately initiate action to deny the enemy opportunity of such an attack. Surface radars will ascertain courses, speeds, numbers, and, if possible, approximate sizes of targets.

The functions of such components are especially important at night and during periods of low visibility when visual detection and challenge may be impossible.

A surface search component may be assigned to cover not only the approaches to a harbor but an entire area. In this case, only the radars covering the harbor approaches will report directly to HECP, while outlying radars will report all surface targets to base operations which will, in turn, advise HECP of any contacts standing in towards the harbor. If all radars, HECP and base operations are on a single reporting line or radio circuit, this latter action on the part of base operations will be unnecessary.

Any surface detection radar, in order to perform its various duties with maximum speed and efficiency, must have satisfactory communications not only with other radars in its immediate area, but also with HECP, the detection stations, base operations office, and ADCC. Since in many areas land lines may be impracticable, suitable radio communications must be set up, frequencies must be assigned, and equipment procured which is sufficiently powerful to maintain reliable contact with other stations on the circuit, regardless of distances, land contours, frequent bad weather, and local disturbances or interference. The harbor defense



An SG–2S tower and antenna in the process of construction at the Naval Training Center, San Pedro, Calif.

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officer must see to it that all components under his cognizance are adequately provided for along these lines and are 100 percent operative all the time.

If, at night or during periods of low visibility, a radar picks up a surface target nearing the approaches to the harbor, the information should immediately be relayed to HECP which will forward the information without delay to base operations. The radar will continue to track and send in reports on the target until advised by HECP that the loop adjunct radar has the target and further information is unnecessary. If the target cannot be identified by IFF, or the IFF indications look at all suspicious, the fact must be reported without delay. A standard operating and reporting procedure covering all features should be set up for each area.

If at any time a radar detects a ship making the wrong approach to a harbor entrance which would lead it through a danger area, HECP must be advised in order that proper warning may be sent out or action taken.

DUTIES OF SURFACE DETECTION COMPONENT

The duties of a surface detection component are as follows:

(*a*) Continuous search for and examination of all contacts within range of each radar not only during darkness and low visibility, but at all times in order that harbor facilities be made aware of ships, convoys, etc., standing in.

(*b*) Tracking of all contacts picked up.

(*c*) Examination for and challenge by IFF.

(*d*) Prompt and accurate reporting either to HECP, base operations and, in the case of low-flying aircraft, to ADCC.

(*e*) To advise HECP of any ship standing in through a danger area (minefields, reefs, etc.).

(*f*) To maintain radar equipment at peak operating efficiency by periodic calibration and maintenance.

(*g*) To identify and report enemy radar jamming when it occurs.

(*h*) To maintain all communication gear (phone and radio) in satisfactory operating condition.

(*i*) To take suitable precautionary security measures both for personnel and equipment.

(*j*) To refrain from breaking security through misuse of voice radio (i.e., names, types and numbers of ships, especially combatant vessels).

(*k*) To maintain proper health and morale at each radar site.

(*l*) To maintain a state of personnel readiness as ordered by the area command.

(*m*) To be thoroughly familiar with the base and harbor defense organization and to understand the part each component plays in this organization, and to be thoroughly cognizant of the aims and objectives of the base and harbor defense organization.

LOCATION

Surface search radars of the type used in surface detection components, unlike most types of air search radars, are not difficult to site. The principal care to be taken is in making sure that the radars have a clear and unobstructed sweep of the area to be searched. For close-in coverage, radar antennae must be mounted as near to the ground and surface of the water as possible, preferably with a gentle slope away from the radar in the direction of the area to be covered. Of course, this cuts down the radar horizon. In some cases, where it is more important to "reach out," the antennae must be mounted either on a 100-foot tower (which certain sets are equipped with) or on high ground, or both. Radars to be used as harbor detection adjunct radars must be sited to give the earliest possible warning of approaching contacts. Attention must be paid to the most probable direction from which enemy surface craft might approach.

TYPES OF RADARS

Surface search radar components consist of fixed surface search types and mobile surface search types. All units are complete with IFF equipment. The fixed surface search radar utilizes, when needed, a 100-foot tower and is a permanent installation. The mobile surface search radar is either truck or trailer mounted and can be in operation within one half-hour after reaching its site.

However, this equipment is generally not as stable as the fixed surface search set and is usually used only as a stand-by set or in an emergency. In case of extensive activity in an area it can be used in conjunction with the fixed set to search and track. The fixed surface search radar is capable of greater ranges than the mobile set.

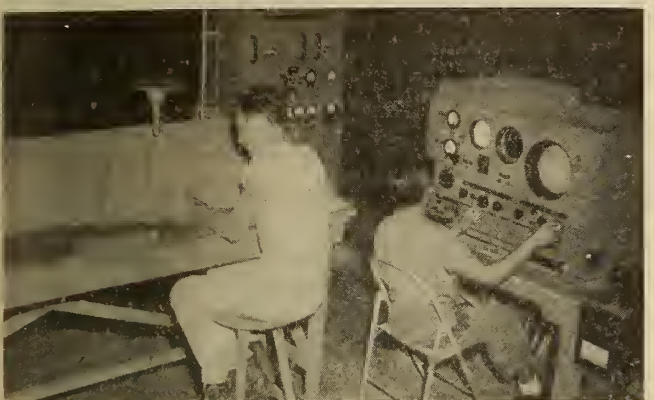
SG–2S SEES ALL

The following observations of unusual radar targets were made at San Pedro, California; during the normal course of advanced training of Navy surface detection radar components.

The SG–2S radar used in these observations was located directly above the HECP at Fort MacArthur

with temperature at 70° F. and elevation of the antenna at 340 feet. Observations started at 0800 and at 0830, respectively, 3 October 1944.

Since there are too many variables in atmosphere, temperature and other such characteristics that enter into results of this type, it cannot be expected that the SG–2S will always give these unusual results.



A watchstander is standing his watch on the SG–2S receiver while plotter traces contacts.

The target in the first observation turned out to be Guadalupe Island, Mexico, which is 546,000 yards distant, elevation 4100 feet. Comments by the Officer-in-Charge of the components are as follows:

Repetition frequencies		Bearing	Ranges	
			Scope	Actual
A	725	Center 180°	84,000 yds. (approx.)	536,312
B	700	Right edge 179°	65,500 yds	533,884
C	675	Left edge 181°	48,100 yds	533,868

"In receiving third returns on the 'A' Scope, they began at 48,500 yards, extending across to 53,400 yards, then again at 58,900 to 63,900. The bearing of the farther target was 1° less in width. Many pips stood up to saturation. On the PPI the returns were bright, giving the appearance of a small island behind the Catalina. The above returns were on the 'C' frequency with vernier set at 10.

"On the 'A' frequency, they were completely off the scope.

"On the 'B' frequency, vernier 10, 179°–183°, 64,200–69,300 yards, 75,000–80,000 yards.

"These returns are evidently from Guadalupe Island since there is no other land at this bearing. The returns were definitely from land as they remained in the same position and range over a period of time and have been received before. Also they did not have the characteristics of ship echoes."

The target on the second observation is presumed to have been a ship. Comments by the Officer in Charge are as follows:

Repetition frequencies	Bearing	Ranges	
		Scope	Actual
A	Center 269°	61,800 yds	287,956
B	Right edge	53,400 yds	287,592
C	Left edge	45,000 yds	287,874

This return was undoubtedly a ship, since (1) it moved, (2) it followed a definite course toward San Pedro, and (3) the pip pulsated in the manner characteristic of ship echoes. The following fixes were obtained on this target:

Bearing	*Range*
269	48,500
268	46,600
266	40,000
265	39,000
260	37,000
265	24,000
264	20,000

The target was lost after this last fix. The course was determined to be 093° with a speed of 13 knots and was followed into the blanked-out space of the radar, lost until it came into range of first returns, and then tracked on into the harbor.

Note the different relationships between the frequencies; namely, 8,400 yards. On report No. 1 this variation is around 17,500 yards which might lead one to believe that perhaps the returns from the ship were second sweep and those from the land third sweep.

In an effort to determine the repetition rate at the three frequency settings of the SG–2S and thus determine the total elapsed time between sweeps, the procedures describeed in the following paragraphs were performed:

An attempt was made to secure an accurate frequency meter that would measure the low frequencies of the SG–2S but none was available. However, a Hewlett Packard audio oscillator that was said to be calibrated to within five cycles was obtained.

By synchronizing the sweep triggering pulse taken from E402 at terminals 45 and 46, with various signals from the audio oscillator at first 1:1 and then 2:1 ratios on an RF°O=5 Hickok oscillograph, the following frequencies were determined:

Pulse frequency switch	Vernier control R 407	frequency
A	10	725
B	10	700
C	10	675

At the above repetition frequencies the total range to

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the target received as third returns (report No. 1) was computed as follows:

Pulse freq.	Vernier control	Repet. freq.	Time u/sec.	Range (yards) 1st sweep	Range (yards) 2d sweep	Range (yards) 3d sweep	Total range to target
A	10	725	1379	226,156	226,156	[1] 84,000	536,312
B	10	700	1428	234,192	234,192	65,500	533,884
C	10	675	1481	242,884	242,884	48,100	533,868

[1] Approximate.

The total range to the second return echoes recorded in report No. 2 were computed as follows.

Pulse freq.	Vernier control	freq. Repet.	Time u /sec.	Range (yards) 1st sweep	Range (yards) 2d sweep	Total range to target
A	10	725	1481	226,156	61,800	287,956
B	10	700	1428	234,192	53,400	287,592
C	10	675	1379	242,884	45,000	287,884

THE SO–7 M/N AND SO–12 M/N RADAR

On a PPI scope showing a map-like picture of the surrounding terrain and water a tiny moving speck of light appeared. The range indicator pointed to the 1,140-yard mark. A target had presented itself on the screen of a radar. If this had taken place at an advanced base a report would have been made to HECP and an investigation started to determine what this target was. As it happened, the target was known to be a swimmer, with only his head showing above the surface of the water. The equipment that detected it at this distance was the SO–12 M/N radar.

In the early days of the war the only surface search radars were designed for use aboard ship, and the supply was so limited that they were only furnished to major ships of the fleet. As time passed, a definite need for a shore-based surface search radar was felt, and the Marine Corps designed and developed the SO–7 M/N, a modification of the Navy shipboard SO radar series.

The SO–7M is a medium range land-based portable equipment designed primarily for search over the surface of the water. It is identical with the SO–7N

The mobile SO–7M set is in preparation to go into operation.

except for mounting, the "M" being built on a frame which is bolted to a Marine Corps truck bed and the "N" being mounted on a trailer. It can be driven to any desired location and put into operation within two or three hours after arrival.

This surface search equipment has an average maximum range of 20 miles, the range depending on the location, size and character of the target and to some extent on weather conditions.

A later model, the SO–12 M/N is very similar to the SO–7M with certain improvements. The spark gap modulator on the SO–7 is replaced by a hydrogron thyratron, the frequency of the SO–12 is higher and the use of a sharp beam antenna produces well defined images and results in increased range as compared with the SO–7. The use of the X-band transmission gives good images of small targets on or near the surface of the water—a point which is particularly important since the sneakcraft, one-man sub, human torpedo, and swimmer made their appearance in modern warfare.

When radar systems SO–12 M/N and SO–7 M/N were tested by the Naval Research Laboratory to compare their operational characteristics on surface craft and low-flying planes, the SO–12 was found to be superior to the SO–7 in detection and tracking. The SO–7 gave superior performance on aircraft flying between 1,000 and 4,000 feet because of its wider vertical beam width. However, when a 4° beam feed was installed on the SO–12 its performance on high-flying planes was improved.

A number of improvement kits for SO–12 M/N radars have come off the assembly line which will improve the performance of this set. A power unit kit, a four-cylinder air-cooled engine, promised to solve the power unit difficulties. Other kits now supplied or planned for production are for sector scanning, antenna speed control and direction I.F.F. antenna modification.

The end of the war came before the SO–12 could be put into operation at advanced bases as loop adjuncts and in surface detection components. However, use of this equipment in continental United States indicates it is the answer to the Navy and Marine Corps problem of shore-based surface detection. It has also been adopted by the Army for anti-aircraft batteries for the detection of low-flying planes.

SO–7 M/N RANGES

The following are reports of tests made on an SO–7M (Mobile Surface Search) Radar by Argus Assembly and Training Detachment at Hueneme, California, and by Argus Unit No. 26 at MCAS, Santa Barbara, Calif. Tests were made during the period 11 March to 17 March 1944. No barometric readings were taken.

A narrative form of operational results obtained at Hueneme follows:

"Weather clear, high wind (gusty), temperature about 60 degrees, water choppy, visibility unlimited. Site elevation approximately 18 feet above sea level, equipment spotted approximately 20 feet inland with the base of the trailer slightly below the top of a boulder breakwater and about 450 yards from the entrance to the harbor. Time required to place equipment in operation (two men) about two hours. (Note: This due primarily to time required in breaking out auxiliary gasoline engine and placing in operation for initial run-in. The main power plant, which is an integral part of the SO–7M, was damaged in transit.) The scope presentation (PPI) was exceptionally clear and distinct. Permanent echoes were observed at a range of 65 miles, these consisting of mountains up and down the coast and immediately inland. Patrol craft were tracked at 10,000 yards up and down the beach for the first two hours of operation. A vessel of the Liberty class departed about 1300 heading roughly 220 (the antenna was not exactly oriented for this test) and was tracked until no longer visible on the scope.

"The return echo was very sharp and unmistakable for the first 16,000 yards, and up to 10,000 yards the small escort craft was separate and distinct on the scope. No fading occurred until the vessel reached a range of 28,000 yards. At 36,000 yards it became necessary to stop the antenna directly on the target in order to detect its presence. At 39,000 yards the target disappeared entirely. Shortly thereafter an LST was picked up about 3,000 yards off the beach, and a track was made of its approach to the harbor. Using the four-mile range scale, this vessel was tracked up the coast and into the harbor entrance (a distance of 450 yards from the equipment site). It was noted on the four-mile range scale the receiver had to be detuned considerably from its peak in order to have distinguishable targets within 4,000 yards. The gain control in itself could not accomplish this. It should be emphasized, however, that this serves no disadvantage and should not be considered as detrimental to the overall functioning of the equipment. The tuning control is as readily accessible as is the gain control, and the receiver can be repeaked with ease and precision upon shifting to a longer range. The tremendous amount of gain in the receiver produced a complete blur for the first 4,000 yards on the four-mile

scale, but this effect was not apparent on either of the other scales.

"Due to the moderately bad weather a few plane flights were available for tracking. The few flights noted were comparatively close in (about 20,000 yards) and these gave rather erratic return echoes which leads to the belief that tracking plane flights would be difficult to impossible, except for low-flying aircraft.

"Assuming the power plants have been serviced previously and are operative, and no equipment failures occur during the starting period, the estimated time requirements for placing the set in operation (one technician) follows:

	Minutes
Laying back canvas cover	5
Attaching power and control cables	5
Elevating and levelling antenna	10
Starting equipment and orienting antenna	10
Total time required	30

Three experienced operators should accomplish this well under one-half the above noted time."

Excerpts from the test made by Argus Unit No. 26 at USMCAS, Santa Barbara, Calif., follow:

"The SO–7M has been in operation for the period 11 March to 17 March 1944, and during that time its operation and performance have been highly satisfactory.

"Permanent echoes have been received a distance of 95 miles, surface targets at 20 miles (miles are nautical), and aircraft at 79 miles. (Site 70′ above sea.)

"The greatest calibrated range on the SO–7M is 80 miles, but by condensing the sweep length, which is quite linear, a range of almost 100 miles can be obtained. Permanent land echoes were received on this range to the very end of the sweep and the targets identified with the aid of a map. The tip of Santa Catalina Island came in strongly, as did Point Vicente (the promontory below Los Angeles on which San Pedro is located). Santa Barbara Island could be seen readily, as well as the group of islands south of the city of Santa Barbara. Distinguishable also on this range was an accurate map of the coastline from Point Conception to Point Vicente.

"Surface targets have been observed at a range of 20 miles, confirmed by visual lookout, but it is believed that a greater range can be obtained, at least to the optical horizon.

"Aircraft have been observed at a range of 79 miles. Due to the innate characteristics of this equipment it can pick up only low-flying aircraft—probably no higher than a ceiling of 1,500 or 2,000 feet.

"A remarkable demonstration of the capabilities of this equipment was noted on the screen and confirmed by a visual lookout when a flight of TBF's was observed making torpedo runs at a distance of 10 miles offshore. The rather large echo on the screen showing the original flight was seen to separate into individual targets as the planes made their runs and then merged again into the reassembled flight.

"The only disadvantage of this equipment is the lack of hand rotation of the antenna to permit greater accuracy in determining azimuth."

The prime advantages of this type of equipment lie in its extreme mobility and ability to commence operations almost immediately upon "hitting the beach." If used in an assault stage, it is of inestimable value to the forces ashore in determining during periods of darkness or low visibility the line of transports, progress of each landing wave as it approaches the beach, and a general layout picture of the whole area. Furthermore, its ability to track low-flying aircraft offers excellent warning against strafing and low-level bombing attacks by the enemy in an attempt to deny our forces a beachhead.

Taking into consideration the height of the antenna at Goleta and the height of the land at San Clemente Island, the computed horizon distance would be 43.8 miles; yet, a strong permanent echo was received from San Clemente 95 miles away. Santa Barbara Island was visible on the scope at 65 miles while the line of sight visibility for the antenna height and the elevation of Santa Barbara Island is only 35.2 miles.

Of more interest, from the standpoint of warning and defense, is the fact that a Liberty ship was tracked out to 39,000 yards from the sea-level site at Hueneme and a ship of unidentified size was observed and tracked at 40,000 yards from the 70-foot site at Goleta. In addition to this, the ability to track and watch torpedo planes making their runs is invaluable to the proper defense of a base. It is to be remembered, however, that the equipment upon which the tests were made was operating under ideal climatic conditions, was new and as yet had not been exposed to rough handling, excessive humidity, and prolonged exposure to salt air. Since no reports of failures in the forward areas were received, it is assumed that, with proper care and maintenance, the equipment is well able to stand up under adverse conditions.

One SO–7 M/N radar is standard equipment in each B3 component while one SO–7M/N and one SG–2S are standard in each B7 component and two SO–7M/N and three SG–2S in each B6 component.

When an underwater or surface detection unit arrives at Island "X" as part of the harbor or base defense facilities, the SO–7M/N can be set up and operating within a very few minutes of the time it is sited. The SG–2S, on the other hand, requires a great deal of preparation before it can commence operations. With help from larger activities, the SG–2S should be "on the air" in a week.

Due to its size and mobility the SO–7M/N can be moved with ease from point to point as the occasion

demands and, if advisable, can be revetted at each site with relatively little trouble.

The SO–7M is truck-mounted and utilizes a two-wheel trailer for spares, while the SO–7N is trailer-mounted, with the same spare parts trailer, and uses a jeep as motive power. Siting of this equipment is important only insofar as unobstructed coverage is concerned. The background is of no consequence.

TRAPPED RADAR WAVES GIVE INCREASED RANGES

In the early days of radar, topics such as ducts, anomalous propagation, bending, and the like were unheard of except possibly in laboratories and text books. Unusual radar ranges reported occasionally by ships were generally passed off as a freak of nature. The so-called freak of nature has, however, been steadily increasing in importance. It has been the subject of lengthy and exhaustive tests in various parts of the world. As yet, we have barely "scratched" the surface. We are gradually finding out that in certain areas at certain times of the year with certain weather conditions, radars of different wave lengths operate more efficiently at different antenna heights.

Under normal operation, a surface search radar might pick up a large ship at 20 miles, which is a satisfactory range. On the other hand, by experimenting with antenna heights, the range might be increased as much as three or four times. We know now that the highest possible site for radars of some wave lengths does not always give the best results.

The SG radar tower and operations hut at an advanced base.

It has now come down to a question of ducts, duct width, wind, weather, and moisture. Studies which have been made show the relatively short distance to the horizon as well as the possibility of extreme ranges if the radar waves are trapped in a duct and must follow the curve of the earth's surface. Possibilities are limitless, depending on the power of the radar.

In recent tests, atmospheric ducts, which trap radar waves over the open ocean in the trade wind belts, have been proved to be very persistent and may be put to use in extending the surface range of radars beyond the horizon. Of course, a radar which has the ability to track targets out to the horizon must be used or the ducts will be of little value in extending surface ranges. These tests have been conducted in many areas around the world.

While these tests, the results of which are given in this article, were not run on the standard radar equipment of B3 and B7 components, they were run on equipment which covered the same bands; namely, the X- and S-bands. The SO–7M/N and the SG–2S are S-band sets, and SO–12M/N is an X-band set.

A 94-foot tower was used with both X- and S-band receiving antennas at heights of 14, 24, 54, and 94 feet above sea level to obtain the maximum ranges, consistency and variation of signal strength of signals transmitted from a PC. An additional X-band receiving antenna at six feet was later installed when it was found that low heights gave improved duct transmission. The PC transmitted X- and S-band signals from two levels, 14 and 46 feet. The different levels were used to determine the optimum antenna height in the duct.

Flexibility with respect to antenna height is possible with the SG–2S radar. All or any part of the standard 100-foot antenna tower may be used to give the best height for a particular area. The SO–7/12/MN radars being mobile-mounted may readily utilize land elevations to change antenna heights.

To obtain the height of the ducts, simultaneous meteorological observations were made on the ship and on shore. Ducts were found to be present all the time with height varying between 20 and 50 feet, depending on the speed of the wind.

A typical test procedure was to start the PC close in and travel straight out from the tower until the X- and S-band signals could not be detected at any level. The maximum range obtained for both X- and S-band sig-

nals was 180 miles (one-way transmission). The maximum reliable ranges are probably around 100 miles. The fact that one-way transmission could be detected as far as 180 miles means that under these low-level duct conditions one of our radars could be intercepted by the Japs at 180 miles, although the Jap would not be detected by our radar. Thus, it should be kept in mind that ducts also increase the range at which the enemy may intercept our signals.

After many measurements were made with one-way transmission from PC to shore, an APS–15 was set up at the above-mentioned levels to see how far the ship could be tracked. The maximum range obtained with an antenna height of six feet was 47 miles. From these results, it is estimated that large targets such as a battleship, cruiser, or carrier could be detected at ranges as far as 80 to 90 miles. Ranges on convoys and task forces might even be greater.

The performance of the APS–15 is very similar to the SO–12M/N, both being X-band radar.

Many more facts of operational importance were determined during these particular tests. They are summarized as follows:

1. These ducts are persistent throughout the trade wind region over the ocean areas where winds prevail from 8 to 30 knots.

2. Strength of trapping is dependent upon wind conditions, falling off considerably for winds less than 10 knots and increasing to an optimum condition with winds around 15 to 20 knots.

3. They affect radio and radar sets operating at S-band or higher, particularly on frequencies in the X-band above.

4. The lowest possible antenna height for X-band (6 to 15 feet) is the optimum location for increased surface or extremely low-flying plane coverage.

5. S-band sets are affected by duct conditions, but the higher antenna elevations up to at least 100 feet produce the best results. Best protection against planes at about 100 feet is provided by S-band sets at 100 feet.

6. X-band radar ranges have been extended to over 40 miles on small surface craft such as a PC using AN/APS–15 with unmodified parabolic antenna at 6-foot elevation. Larger ships of the fleet (cruisers, battleships, carriers) may quite likely be detected at ranges of 80 to 90 miles with the low antenna locations.

7. Increases in radar ranges of 30 percent beyond the horizon may be expected on high powered S-band radars.

8. Radar stations may be located inland from the water's edge, even though the duct is rapidly destroyed inland, and still make effective use of duct transmission. The effect of increased antenna height because of increasing ground elevation is similar to increased antenna height at the water's edge.

9. The use of these ducts for over-water communication on S-band and above probably will be useful to ranges of 100 miles or more. Further experiments to determine the fading of signals in duct propagation are necessary to verify this.

10. Operational security may be seriously endangered for units operating radar in these areas up to 180 miles.

11. The measure of insurance for protection against approaching aircraft or groups of aircraft at deck heights (15 feet) is appreciably increased by using X-band radars at very low heights.

12. Present radar antenna heights could not be lowered, but additional installations of X-band radar at the lowest height practicable is desirable.

FORWARD — THE ARGUS RADAR UNIT

The Argus unit is a radar component that "broke the ice" for shore-based air warning radar in the war just ended, but its life beyond that point was very short lived.

The material that is printed on the following pages concerning the Argus unit will be of no major assistance to a student of present-day harbor defenses other than the fact that he can become acquainted with shore-based air warning defenses, the way the units were organized, their purpose, and the personnel and equipment allotted to them. The units, after fulfilling a valuable mission at forward bases during the early and middle stages of the war, were decommissioned by the Navy with their functions being taken over by the Army and Marine Corps.

ARGUS UNITS

One of the types of coordinated radar components which played a highly important part in the defense of the islands of the Pacific was the Argus unit, organized during the early months of the war and trained by the

Navy.

The mission of an Argus unit was to provide, during the developmental stage of an advanced Naval base, a comprehensive air warning, surface warning and fighter direction organization which would coordinate all radar operation under the local area commander. This mission was in keeping with the idea of using Pacific Islands as "unsinkable aircraft carriers."

ARGUS HISTORY

Early in 1942 the need was felt for coordinated air warning units at advanced bases for use from the time the Navy occupied the area until the Army took over responsibilities of base defense. A letter was written by CNO requesting information on radar equipments which would give early warning of enemy aircraft. The following June a directive established the air base radar units to be called "Argus units" and requested the bureaus to make recommendations relative to the entire personnel and material requirements for these units after consulting the U. S. Marine Corps and Army.

In setting up the program, many difficulties were encountered in connection with material which had to be obtained from the Army, facilities and personnel. As no Navy shore-based radar program existed, training courses were initiated for fighter director officers as well as radar maintenance officers and men. A team training establishment was set up at A.B.D., Port Hueneme, California.

The first unit was ordered assembled on 15 October 1942 but repeated delays were encountered in obtaining equipment. This unit was finally assembled in late February and sailed 10 March 1943 with a large proportion of stop-gap material. Other units, however, followed

The SCR–270 radar is ready to operate at Barbers Point, Oahu, T.H.

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more rapidly, and a general average of about three per month was maintained after April, 1943.

During 1943 there were many changes and improvements made in equipment and training until both had reached a high state of proficiency. The program then was discontinued by the Navy, with the functions of air warning being taken over by the Marines.

ORGANIZATION

The organization of Argus units, listed as K4 Advanced Base Functional Components, after a year of evolution is shown in detail in Appendix A. The complement for the Argus unit was set at 21 officers and 178 enlisted men. Approximately half of the officers had A-V(S) classifications with fighter direction training which they had received at the U. S. Naval Radar Training School at St. Simon's Island, Georgia. Three E-V(RS) officers, who had received technical training in radar at Harvard and M.I.T. Radar Schools, were also included.

Other functional components were added to the K4 component to make it a self-sustaining unit if it were not to be attached to a Lion, Cub, or other advanced base assembly. In all cases, two 25-men camp components were added for the use of outpost teams overseas.

TRAINING

The training of Argus was divided into three phases. The primary training of the units at Port Hueneme, Calif., was of six weeks' duration. In the first three weeks a watch bill was assigned, a series of classes run, and a schedule followed whereby operators and scope readers assigned for practice on training-detachment radar equipments received supervised instruction. At the same time the operators and scope readers were training, the technicians broke out the equipments assigned to the unit, set it up, serviced it for use, and established regular watches. The second three weeks included operations as a unit, running interception problems with planes from Terminal Island and operating the C.I.C. under simulated combat conditions.

At the end of the sixth week, the unit moved to San Clemente Island, taking its equipment on an L.S.T. and simulating an amphibious landing. The equipment was set up and operated on San Clemente, with various types of training being provided and involving different types of interceptions and amphibious landings. During this period of one month, the unit was drawn closely together and better integrated into a coordinated team.

The third phase of the training was carried out at various air fields on the West coast, ranging from Washington to the Mexican border. At the air fields Argus personnel trained with and taught fighter direction principles to pilots. Air raids were simulated by Army and Marine pilots, giving the operators experience in locating the raids, tracking and intercepting. Here the AN/TTQ equipment was set up and the entire unit operated as an Air Defense Control Center. Experience was gained also in night control, in homing lost planes, in air-sea rescue, in searchlight and AA control, and in all other functions likely to be required in the combat area.

OPERATIONS

The Argus unit was taken ashore as soon after D-Day as security permitted with the radars being set up at pre-determined locations which were selected from studies made of terrain. Siting the sets was an important step since the locations were selected to give the greatest coverage with the fewest number of blind spots.

The Combat Information Center was located at a

The Argus 12 site near landing strip, Barbers Point, Oahu.

central point near the air strip, the SCR–270 (long range air search) and the SCR–527 (ground control interception) radars being located at the pre-determined sites, and the transportable air search or outpost radars strategically located at distant points on the island. Power telephones and radio connections were made between CIC and all radars, lookouts, and command posts on the island. All information of air traffic received by CIC from the radars was plotted and the fighter planes directed by radio from this control center. In this way, advance warning of enemy raids was obtained, the island alerted, and the pilots sent out to intercept, shoot down or turn back enemy planes oftentimes before they reached the island. Comparatively few raids ever reached their targets, and the lives of thousands of ground personnel together with much valuable equipment were saved.

The functions of the Argus units were assumed by the U. S. Marine Corps in early 1944 and performed by Marine Air Warning Units. These units with a similar organization took over the air warning defense of Pacific islands during the assault stage.

Postwar plans call for the consolidation of the Naval Training School (Tactical Radar) at Hollywood, Florida, and Naval Radar Training School at St. Simons Island, Georgia, for training in CIC and all related subjects. This activity established as an Electronics Training Center will be located at Key West, Fla., and will provide training for both officer and enlisted personnel in C.I.C. (Tactical Radar), radar operations, ground control approach, pilotless aircraft, electronics countermeasures, NANCY training, and airborne operation. Fleet Training Center, Oahu, has absorbed all Pacific fleet radar and related instruction.

These activities will provide for sufficient training of personnel for use in the peace time fleet and provide facilities for expansion in case of any future emergency.

APPENDIX A

Standard Argus Unit

Code	Description	Officers	Men	Weight	Cube
D12 [1]	Supply component (small)	0	5	7	40
G10	Dispensary, 10 bed, mobile	1	3	3	8
J4C	Base demolition	0	0	1	2
(2)J15A [2]	Personnel arms	0	0	6	24
(25)J15B	Officer arms	0	0	0	0
K4	Detection, Fighter Direction and Combat Information Center.	20	178	209	1,000
(3)N3A	Camp, 50 men, tents	0	18	270	600
(3)N4A	Camp, 25 men, tents	0	9	195	480
	Totals	21	213	691	2,154

[1] Supply officer deleted (included in K4).

[2] Modified to include hand grenades and additional submachine guns.

NOTE 1.—Two standard N4A components will be shipped in all cases with the K4 for outpost use overseas.

NOTE 2—The above is a complete self-sustaining unit. When a unit is not desired to be self-sustaining, the G and N3A components and one (only) N4A component will be deleted.

APPENDIX B

Proposed Organization of K4—List of Teams Constituting the K4 Detection, Fighter Direction and Combat Information Center

The K4 is the major functional component of the Argus unit whose function is to provide fighter direction, air warning, surface warning, combat information service, and coordination of all radars of the base defenses. It is trained as ten coordinated teams, namely:

A. Headquarters and Administration.

B. CIC (Combat Information Center).

C. Secondary CIC.

D. Long range air search No. 1.

E. Long range air search No. 2.

F. GCI (Ground Control of Interception).

G. Surface Search.

H. Outpost radar No. 1.

I. Outpost radar No. 2.

J. Maintenance and repair.

It is desired that two of the standard N4A components shown in a standard Argus unit be included with the shipment of every K4, regardless of whether or not the Argus is intended to be self-sustaining. This provision is essential for the sustaining of isolated outposts necessary for the operation of the K4.

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Major Items of Material

[With proposed team breakdown]

Quantity	Team breakdown (tentative) A	B	C	D	E	F	G	H	I	J	Descriptive (with prototypes)
2				1	1						Mobile long range air search radar with IFF (SCR–270–DA).
1						1					Mobile GCI radar with IFF (SCR-527).
1							1				Mobile surface search radar with IFF (SO–7M).
3			1					1	1		Lightweight air search radar with IFF (SCR–602).
3		2	1								VHF Xmtr. and rcr., long range (BC–639–640).
2		1				1					VHF Xmtr. and rcr., long range (SCR–624).
4		2	1			1					HF mobile long range radio station (SCR–399).
11	1	2	2	1	1	1	1	1	1		HF Transreceiver, short range (TCS).
1		1									HF Xmtr. and receiver, med. range (MM).
1			1								HF Xmtr. and rcr., med. range (SCR–193–alt. MM).
4	1	1	1			1					VHF transreceivers, short range, FM (MN–3).
12	12										VHF transreceivers, ultra-portable (TBY).
2		1	1								HF Receiver (RBG).
1		1									Set CIC intercom system complete with power (AN/TTQ–1).
1		1									Vertical Plot, edge-lit, ship type.
2		2									Plot table, ship type.
1		1									Remote PPI Scope, ship type (VC, VC–1, VD, VD–1, or VE).
40	4	10	10	2	2	4	2	2	2	2	Sound powered head-chest telephone.
2	2										Set advanced base portable telephone system.
4	4										Truck, cargo, 2½ ton, 6 x 6, with winch.
2	2										Truck, cargo, 1½ ton, 4 x 4, with winch.
2	2										Trailer, cargo, 8-ton, with long body.
2	2										Truck, ¾ ton, 4 x 4, weapons carrier.
8	8										Truck, recon., ¼ ton, 4 x 4.
4	4										Trailer, 2 wheel, ¼ ton.
1										1	Truck, 1 ton, fitted for radar, radio and vehicle repair and maintenance.
1										1	Recon. truck, ¼ ton, 4 x 4, fitted for wire laying and maintenance.
1	1										Trailer, cargo, 1 ton, 2 wheel.
1	1										Tractor, crawler, Class II, with angle dozer.
1		1									Special steel magazine, 20 x 30, for CIC.
5	5										Generator, gas or diesel, 15 KW.
2				1				1			N4A Component.
											Housing for technical equipment.
											Kits—CIC, radio, radar, carpenter, electrician, automotive, etc.
											Spares and supporting items as needed.
											Power for all radios.
											Camouflage gear and sandbags.
											First Aid facilities for outpost locations.

Personnel (K4 only): (with proposed team breakdown)

No.	A	B	C	D	E	F	G	H	I	J	Classification or rate officers
11	1	4	3			3					A–V(S).
2	2										D–V(S).
1	1										C–V(S).
1	1										SC–V(S).
1	1										E–V(S).
3				1	1	1					E–V(RS).
1			1								A–V(RS).
20											

Personnel (K4 only): (with proposed team breakdown)—cont'd

No.	A	B	C	D	E	F	G	H	I	J	Enlisted
12		1	1	2	2	2	1	1	1	1	RT.
47			3	10	10	14	4	3	3		RdM.
20	1	5	3	2	2	2	1	2	2		RM.
7	1			1	1	2	1			1	MoMM.
8	2	3	1			1				1	EM.
2	2										Y.
1	1										GM.
1	1										CM.
79	20	12	11	9	9	7	3	3	3	2	Sea.
1	1										SK.
178											

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	Instruction Book for Navy Model SO–7 M/N Radar Equipment—BuShips.	General description, installation, operation maintenance, generation and control of power, and I.F.F. information.
	Tentative installation instruction book Navy Model SG–2S Radar Equipment.	General description, installation and illustration.
	Instruction Book for Mark 33—Radar Equipment—BuOrd.	Description, parts and installation.
Eng. 129	Radar Technical Bulletins—BuShips.	General information on radar equipment, maintenance and location of troubles, operation and dictionary of terms.
BuShips 919	Specification for Gasoline Driven Alternator Set for Model SG–2S Radar.	Specification for gas engine driven alternator.
JAN P104	U.S. Radar Handbook Vol. II—National Defense Research Committee.	Brief technical and operational information concerning all U.S. ground radar systems on production development or use.
Report R–2569	Comparative Operational Tests of Radar Systems Mark 33, So–12M and SO–7M.	Comparison of operational characteristics on various specified surface and aircraft targets—minimum and maximum ranges.
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PUBLICATIONS CONCERNING SONAR MATERIEL TRAINING

CONFIDENTIAL — 1 May 1945

The following publications contain information pertinent to instruction in sonar materiel. The issuing office for each publication is listed for convenience; requests for publications should be sent via official channels.

Classification:	*Matériel Handbooks and Manuals*	*Issuing Office*
CONFIDENTIAL or RESTRICTED	MANUFACTURERS' INSTRUCTION BOOKS—covering individual models of equipments. (Preliminary books are issued with equipment—final books later.)	BuShips (250F)
RESTRICTED	Sonar Equipment MAINTENANCE MANUALS—prepared by BuShips–NDRC for the following equipments only: QBE Series, (NavShips 900,066) *QCS, QCS–1, QCT, QCT–1, QCQ–1, QCR–1, (NavShips 900,026) *QCQ–2, (NavShips 900,046) QGA, (NavShips 900,068) *WCA, WCA–1, (NavShips 900,045) WCA–2, (NavShips 900,067) WEA–2, (NavShips 900,042) JP–1, JP–2, JP–3, (NavShips 900,043) *BDI Model X–3 for CBM, CDI, CQA, (NavShips 900,047) CRYSTAL PROJECTORS, (NavShips 900,044) *Already distributed—the others are being prepared or printed.	BuShips (250F)
CONFIDENTIAL	NDRC MANUAL FOR ASW FIELD ENGINEERS—(CUDWR–OSRD–NDRC Sec. 6.1) (Not an officially approved publication.)	BuShips (250F)
RESTRICTED	SONAR MAINTENANCE HANDBOOK—U.S. Navy (1944) (West Coast Sound Training Squadron, WCSS San Diego).	BuShips (250F)
RESTRICTED	NOTES ON SERVICING RADIO AND SOUND EQUIPMENT—1942 Edition, U.S. Navy (West Coast Sound Training Squadron, WCSS San Diego).	BuShips (250F)
RESTRICTED	BUREAU OF SHIPS MANUAL	BuShips (250)
RESTRICTED	Bureau of Ships Manual Chapter 67—RADIO EQUIPMENT (1944).	BuShips (250)
RESTRICTED	Bureau of Ships Manual Chapter 68—INSTRUCTIONS FOR THE OPERATION AND MAINTENANCE OF UNDERWATER SOUND APPARATUS (1943).	BuShips (250)
CONFIDENTIAL	SHIPBOARD SONAR TYPE ALLOWANCE LIST	BuShips (983)
RESTRICTED	SONAR EQUIPMENT LOG—U.S. Navy, NavShips 900,023	RMOs or BuShips (250F)
RESTRICTED	HARBOR DETECTION BULLETIN, NavShips 900,024.1 (June 1944)	BuShips (903)

SURFACE DETECTION RADAR

Classification:		Issuing Office
	Matériel Periodicals	
RESTRICTED	("RIB") RADIO INSTALLATION BULLETIN—NavShips 900,022 Shipboard Radio-Radar-Sonar Materials and Installations, (not available to ships, except tenders). (Published weekly.)	BuShips (993)
RESTRICTED	SONAR BULLETIN—NavShips 900,025.5 BuShips (Revised annually, supplements issued monthly.)	RMOs BuShips (250F)
RESTRICTED	RADIO AND SOUND BULLETIN—BuShips NavShips 900,011. (Issued quarterly.)	BuShips (250F)
RESTRICTED	SUMMARY OF COMPONENT FAILURES—SHIPBOARD SONAR EQUIPMENT (available to matériel schools.) (Published monthly.)	BuShips (983)
	Operational Publications Containing Information on Matériel	
CONFIDENTIAL	U.S. FLEET ANTI-SUBMARINE AND ESCORT OF CONVOY INSTRUCTIONS—1945 (FTP 223A). Contains matériel notes in addition to tactical doctrine.	RPIOs after approval by ComTENTHFlt
CONFIDENTIAL	U.S. NAVY TRAINING COURSE for SoM3/c and SoM2/c (1944). (Contains sections on physics of sound and elementary sonar materiel) NavPers 10125.	BuPers (Training Aids)
CONFIDENTIAL	U.S. NAVY TRAINING COURSE for SoM1/c and CSoM. (Being prepared.)	BuPers (Training Aids)
CONFIDENTIAL	HARBOR UNDERWATER DETECTION, Surface and Submarine Warning Notes, (OpNav 30-3E-B). (Published bi-monthly.)	CNO (Op-30)
	Bathythermograph Publications	
CONFIDENTIAL	PREDICTION OF SOUND RANGES FROM BATHYTHERMOGRAPH OBSERVATIONS, NavShips 943-C2. (NDRC-March 1944.)	BuShips (250F)
CONFIDENTIAL	SUBMARINE LISTENING RANGES, NavShips 943-G (NDRC).	
CONFIDENTIAL	USE OF SUBMARINE BATHYTHERMOGRAPH OBSERVATIONS, NavShips, 900,069. (Being prepared.)	BuShips (250F)
CONFIDENTIAL	THE USE OF BOTTOM SEDIMENT CHARTS H.O. Misc. 10799 (May 1943)	Hydrographic Office
CONFIDENTIAL and RESTRICTED	BOTTOM SEDIMENT CHARTS (specify regular H.O. Chart number with suffix "A")	Hydrographic Office
RESTRICTED	SOUND RANGING CHARTS OF THE OCEANS (H.O. 1400R, 1401R, 2600R, 2601R, 2603R)	Hydrographic Office
CONFIDENTIAL	WORKBOOK FOR PREDICTION OF MAXIMUM ECHO RANGING—NavShips 900,055 (Note: NavShips number printed on some publications is erroneously, 900,050)	BuShips (250F)
	General Catalogs	
CONFIDENTIAL	LIST OF NAVAL RADIO AND SONAR EQUIPMENT—Ships 242a	RPIOs after approval by BuShips (250F)
CONFIDENTIAL	CATALOG OF NAVAL RADIO EQUIPMENT—Ships 275 (Includes Harbor Detection Equipment—HERALD, etc.)	RPIOs after approval by BuShips (250F)
RESTRICTED	CATALOG OF UNITED STATES NAVY TRAINING FILMS NavAer TF-22. (Published quarterly, latest edition TF-22-10, March 1945.)	BuPers (Training Aids)
CONFIDENTIAL	CATALOG OF UNITED STATES NAVY TRAINING FILMS NavAer TF-13. (Confidential Films Only.) (Published semi-annually, latest edition NavAer TF-22-9 Nov 1944.)	BuPers (Training Aids)

NTSCH (RADIO MATERIEL) NRL BELLEVUE PUBLICATIONS

Bureau Publications

CEMB—NAVSHIPS 900,020.
Radio Type Allowance Booklet—RE 11A-100.
Radio Euipment Log—NAVSHIPS 900,065.
Ordnance Pamphlet (Navy Synchros)—OP-1303.
Radar Electronic Fundamentals—NAVSHIPS 900,016. 6
Radar Equipment Maintenance Bulletin—NAVSHIPS 900,034.
Radar Systems Fundamentals—NAVSHIPS 900,017.
Micro-Wave Techniques—NAVSHIPS 900,028.

Radio Matériel School Publications

Advanced Electronics Fundamental Study Pamphlet.
First 2 weeks, Transmitters, study pamphlet.
2nd 2 weeks, Transmitters, study pamphlet.
Laboratory, Transmitters, study pamphlet.
VF Radar Indicating Equipment Notebook.
VF Radar Indicating Equipment Pamphlet.
Counter Measures Study Pamphlet.
Receivers Study Pamphlet, first two weeks.
Receivers Study Pamphlet, second two weeks.
Introduction to Sonar Study Pamphlet.
QGB Study Pamphlet.
QJB/A Study Pamphlet.
Attack Plotter.
Special Circuits Study Pamphlet.
SC-2 Search Radar Study Pamphlet.
SC-2 Search Radar Student Notebook.
SG-1B Search Radar Study Pamphlet.
MK - Radar Equipment Notebook (includes MK 22).
MK 12 Radar Equipment Pamphlet (includes MK 22).
Countermeasures Laboratory Pamphlet.
I.F.F. Laboratory Experiment Pamphlet.
The RT Guide.

Commercial Reference Text Books

Title	*Author*
Radio Engineering	Terman
Radio Engineers' Handbook	Terman
Communication Engineering	Everitt
The Cathode Ray Tube at Work	Rider
Mathematics for Elec. and Radiomen	Cooke
Radiotron Designers Handbook	F. Langford Smith
Elements of Radio	Marcus and Horton
RCA Receiving Tube Manual RC–1r	RCA Mfg. Co.
RCA Air-Cooled Transmitting Tubes TT3	RCA Mfg. Co.
RCA Tube Handbook Volumes 1–2–3–4	RCA Mfg. Co.
Synchros—Reference Data for RCA Field Engineers	RCA Service Co. Wilson and Horning
Practical Radio Communications	Brainerd—Kaehler—
Ultra High Frequency Techniques	Reich and Woodruff

Instruction book for Navy Model OE–12 Radio Receiver, analyzing equipment—NAVSHIPS 900,260–IB.

Instruction book for Model OD–6 Vacuum Tube Analyzing Equipment.

Instruction book for Model OQ–3 Vacuum Tube Testing Equipment.

Instruction books for the various models of LM Crystal Calibrated Frequency Indicating Equipment:
- LM 19 & 20—NAVSHIPS 900,217–IB.
- LM 14—NAVIER 08 5Q 45.
- LM 13.

Instruction books for Models LR–1 and LR–2 Combined Heterodyne Frequency Meter and Crystal Controlled Calibrator Equipment.

Instruction book for Radio Frequency Signal Generator Equipment Navy Model LP–5—NAVSHIPS 900,425.

Operating Instructions for DU MONT Cathode-Ray Oscillograph Type 1664–E.

Instruction book for TRIUMPH Oscilloscope TYPE CTU–60018, (Mfgs. Type Nr. 830).

Navy Model TBM–5, TBM–7 and TBK–13 Radio Transmitting Equipment—Westinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TBK–16 Radio Transmitting EquipmentWestinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TAJ–14 Radio Telegraph Transmitting Equipment—General Electric GEI–18489.

Prelim; 1B for Navy Model TBL–11 Radio Telegraph Transmitting Equipment—Westinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TBL–7 Radio Telegraph Transmitting Equipment—Westinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TBS–5 Radio Transmitting & Receiving Equipment—RCA Mfg. Co.

Prelim. 1B for Navy Model TDE Radio-Telegraph and Telephone Transmitting Equipment—Westinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TDQ Radio Transmitting Equipment—RCA Mfg. Co.

Prelim. 1B for Navy Model TBW–3 Portable Radio Transmitting Equipment—Westinghouse Elec. & Mfg. Co.

Prelim. 1B for Navy Model TBX–4a Portable Radio Equipment—Hazelgine Electronics Corp.

Instruction book for Navy Model TBY–4 Ultra-portable VHF Transmitting-Receiving Equipment—Colonial Radio Corp.

Navy Model TBS Regular Transmitting and Receiving Equipment—NAVSHIPS 900,000.

Navy Model RCK Radio Receiving Equipment—Scott Radio Laboratories.

Navy Model RAK–8 Radio Receiving Equipment—Magnavox Radio Corporation.

Navy Model RAL–7 Radio Receiving Equipment—RCA Mfg. Co.

Navy Model RBB–1 Radio Receiving Equipment—RCA Mfg. Co.

Navy Model RBC–1 Radio Receiving Equipment—RCA Mfg. Co.

Navy Model RBA–2 Radio Receiving Equipment—Federal Telephone & Radio Corporation.

Navy Model RBL–2/3 Radio Receiving Equipment—National Radio Corporation.

Navy Model DP–13 Radio Direction Finding Equipment—RCA Mfg. Co.

DAE–1 Radio Direction Finding Equipment—RCA Mfg. Co.

DAQ Radio Direction Finding Equipment—Federal Telephone & Radio Corporation.

QCQ1/R1/S/T1 Maintenance Manuals—NAVSHIPS 900–026.

B.D.I. Maintenance Manuals—NAVSHIPS 900–047.

WCA1/2 Maintenance Manuals—NAVSHIPS 900–045.

Crystal Proj. Maintenance Manuals—NAVSHIPS 900–044.

Radar Electronic Fundamentals—NAVSHIPS 900–016.

Sonar Bulletin—NAVSHIPS 900–025.

QGB Echo Finding Equipment Instruction Book—NAVSHIPS 900–341A 1B.

QJB Echo Ranging Equipment Instruction Book—NAVSHIPS 900–238 1B.

MK 1 MOD 2 Attack Plotter—OP 1101.

Model QGA Echo Ranging Equipment—Submarine Signal Co.

Model QCU Echo Ranging Equipment—RCA Mfg. Co.

Model QJA Echo Ranging Equipment—Western Elec. Co.

Model QBE–3a Echo Ranging Equipment—Submarine Signal Co.

Model WEA–3a Echo Ranging Equipment—Submarine Signal Co.

Model QBG Echo Ranging Equipment—Freed Radio.

Model NJ–7 Echo Sounding Equipment—Submarine Signal Co.

Model NJ–8 Echo Sounding Equipment—Bludworth Corp.

Model NJ–9 Echo Sounding Equipment—Submarine Signal Co.

Model NMC Echo Sounding Equipment—RCA Mfg. Co.

Model NMC–1 Echo Sounding Equipment—RCA Mfg. Co.

Model NM–11 Echo Sounding Equipment—Submarine Signal Co.

Model NK–6 Echo Sounding Equipment—Bludworth Corp.

Type CAN 55100 Tactical Range Recorder—Sangamo Elec. Co.

Type CAN 55134 Tactical Range Recorder—Sangamo Elec. Co.

SG–1/SG–a Instruction Book—Eng. 167.

SC–2 Instruction Book Volume 2—Eng. 157.

SK Instruction Book Volume 2—Eng. 189.

OBU–1, OBU–2 Echo Box Radar Test Equipment Instruction Book—Ships 310–A.

OBU–3 Echo Box Radar Test Equipment Instruction Book—Ships 308.

OAA–2 Radar Test Equipment Instruction Book—Ships 227.

Remote PPI—Eng. 203–A.

SC–2 Anti-Jam Receiver Instruction Book—Eng. 2166.

Radar Equipment MK 22 MOD 0—Ships 252–A.

Radar Equipment MK 12 MOD 1—Ships 270–A.

Radar Indicating Equipment Model VF—Ships 288.

U L. Modulator—Signal Generator Instruction Book—NAVSHIPS 900–556.

RDO Radio Receiving Equipment Instruction Book—NAVSHIPS 900–527–1B.

TDY Radio Transmitting Equipment Instruction Book—NAVSHIPS 900–307–1B.

TDY–1 Radio Transmitting Equipment Instruction Book—NAVSHIPS 900–342–1B.

DBM–1 Direction Finder Instruction Book—NAVSHIPS 900–587.
RDP Panoramic Adaptor Instruction Book—Panoramic Radio Corp.
SPA–1 ulse Analyzer Instruction Book—Galvin Mfg. Col.
LAE–1 Signal Generator Instruction Book—Air Radio Co.
LAF Signal Generator Instruction Book—Frank Rieber, Inc.
BL–1 and BL–2 Radio Equipment Instruction Book—Ships 273.
BN Radio Equipment Instruction Book—Ships 232A.
OAP–1 Wavemeter Instruction Book—NAVSHIPS 900–001–1B.
ABK Aircraft Radio Receiving Equipment Instruction Book—CSP 1375.
TS–182/UP IFF Test Equipment Instruction Book—NAVSHIPS 900, 104.
BM Radio Equipment Instruction Book—Eng. 231–A.

Section V

PATROL CRAFT

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Section V—PATROL CRAFT

HARBOR DEFENSE PATROL CRAFT

The use of patrol craft in lanes across the entrance of a harbor is the oldest and still the most important and essential defense that both the Army and Navy have devised. In today's type of harbor defenses, there have been numerous components added to give support to the security of a harbor, but all of them lead to one activity in getting results from their efforts. That activity is the Anti-submarine and Harbor Patrol components—the "Striking Force" of the harbor defense unit.

Patrol craft on guard at the entrance of a harbor is not always limited to the two components included in the harbor defense unit but oftentimes covers a much wider field. Task force commanders at the beginning of the war, during the period of organization of harbor defenses, would send their destroyers to the harbor's entrance when they put in to port to make sure that an enemy submarine did not penetrate the close-in harbor defenses. To give the same support, escort divisions or squadrons would order smaller vessels such as PC's, SC's, YMS's, Frigates, and DE's, to the harbor's entrance after they brought a convoy to port, or assign them to patrol or "ping" line duty and radar guard to seaward of the harbor entrance. In other words, to every officer and man, to every ton of material, and to every ship the security of a continental and advanced base harbor meant the difference in winning and losing of the war. Bases had to be developed in the United States before they could be developed in advanced areas. After advanced bases were won, they, too, had to be developed in order that more could be taken closer to the enemy's homeland. No base could be developed unless there was harbor security to stamp out any threat that the enemy might make through his submarine and sneak craft fleets. Without patrol craft no harbor could be considered adequately defended, regardless of the number of detection, net and artillery defenses that were on hand.

83′ Coast Guard Cutters handle the highly important anti-submarine patrol job for harbor defenses.

In the early part of 1944 a complete revision was made by the Navy in using patrol craft in harbor defenses. In this new plan, arrangements were made with the U. S. Coast Guard to assign 83′ Cutters, manned by Coast Guard personnel, to each harbor defense unit to handle the duties of anti-submarine patrol. Supplementing this most important part of defense, the Navy assigned Harbor Patrol components, consisting of 45′ Picket Boats, to handle the duties of keeping ships safe after they had passed through the harbor's entrance and dropped their anchors.

There was no great revision in the duties of patrol craft. The revision mentioned above came with the order that these patrol craft would be assigned directly to the harbor defense unit to investigate and report to

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HECP on all suspicious or questionable occurrences and contacts, and to carry out such other orders as normally would be required.

This new organizational plan was the beginning of the modern-day defense patrol plan which was in effect at the close of the war, a plan that allowed each harbor defense component to work through the Harbor Entrance Control Post and for HECP to work directly, without delay, with A/S vessels in getting action started on any emergency that arose.

Prior to the acceptance of the new patrol components, A/S vessels were normally attached to forces afloat from where they received their orders. This procedure presented many difficulties to the harbor defense unit. HECP could not expertly direct patrol craft unless the commanding officer of the vessel was thoroughly familiar with the harbor defense plan. Neither could the patrol craft skipper use all of the information which was supplied to him through HECP from the various harbor defense activities unless he was thoroughly acquainted with the functions of each component.

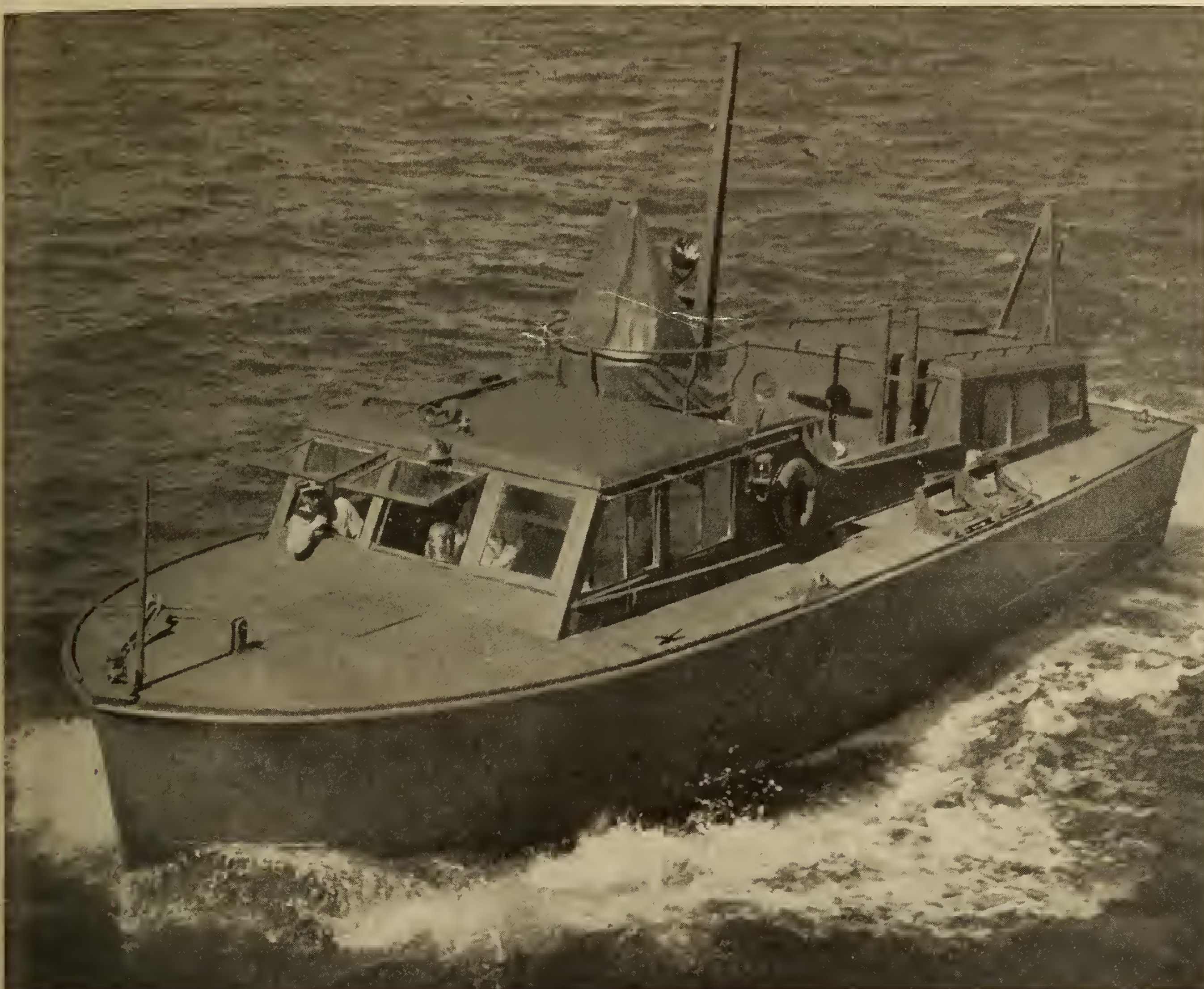
Above all, however, a patrol vessel temporarily assigned to harbor entrance guard is without the tremendous advantages of being completely acquainted with the harbor, knowing the location of unchartered reefs and shoals and the location of all harbor detection devices such as Sono-Buoys and Magnetic Loops.

Two 83′ Cutters working closely together on patrol at a harbor's entrance.

To improve coordination of this "on-again off-again" type of patrol, the Navy ordered the Cutters and their crews to San Pedro, California, the location of the Naval Harbor Defense Center, where a period of indoctrination of harbor defenses was given. Through this course, personnel assigned to HECP, harbor detection, surface detection radar, and nets and booms became acquainted with the two components—anti-submarine and harbor patrol—which would take action on any type of contact they would have. And, at the same time, the patrol craft components learned the functions of the defense components which would furnish them the needed information should a submarine or sneak craft try to make a harbor penetration.

These cutters were not adapted to escort duty or continuous "ping" line duty due to their limited cruising range. They were most effective when held in readiness on slip moorings, ready to get underway promptly and conduct an efficient, coordinated search wherever directed. This also reduced interference with the harbor detection system.

The training program established at San Pedro required a minimum of 30 days after the boats had been made ready for advanced base operations. During this time, the crews would receive training in gunnery and at the West Coast Sound School, San Diego, on tame submarines. Arrangements were made with the Maritime School to teach each member of the crew the art of swimming through burning oil. Emphasis was also placed on fire fighting, small arms firing, radio opera-



45′ Picket Boats are assigned to harbor patrol duties.

tion, signaling by flashing light and semaphore, and extended seamanship exercises for deck hands.

After all harbor defense components at San Pedro had gone through a period of orientation, the harbor defense officer would usually assume command of the harbor defense unit and assign coordinated drills. Through this plan, the harbor defense officer would organize his various components into a well-drilled team, just as they would be required to operate on enemy contacts when they entered the forward area. By careful observation, the harbor defense officer would detect any flaws which resulted, and, during the ensuing days, direct his efforts to correcting them. With several drills of this type, the harbor defense unit would be considered ready for assignment to a forward area, thoroughly qualified to take over the duties of defending a harbor.

Harbor defense officers were taught that high-speed anti-submarine vessels require assigned periods for uninterrupted upkeep in order to operate efficiently and be ready for sea when needed. They would also become familiar, through the training program, with the speed, cruising range, and operational limitations of the cutters.

It will be noted that the training program for patrol vessels at San Pedro did not stress anti-submarine maneuvers and tactics so much as coordinating all defense components to function as one team. The reason such a plan was followed was because practically all of the Coast Guard personnel assigned to San Pedro had had previous duty, in some cases for as long as two or three years, on anti-submarine patrol in the Atlantic. Prior to their Atlantic duty, they had been given anti-submarine indoctrination in training schools. By adding years of experience to their training, they were considered qualified to hunt down a submarine. The train-

It is the job of these 45-footers to keep the inner harbors free of enemy sneak attempts.

ing and experience which they lacked was that of working with a harbor defense unit. Only refresher training was considered necessary in anti-submarine and "Hunter-Killer group" tactics.

The cutters carried a crew of one officer and 13 men and were equipped with radio, radar, echo-ranging gear, depth charges, and Mark XX rocket projectors. Top speed was about 16 knots. Before shipment overseas, the crews of the cutters carefully checked the cutters to make sure that there was an ample supply of spare parts, that each cutter was in operating order and prepared to assume its duty after arrival overseas, and that adequate supplies in foul-weather gear and provisions were on board. If any repairs were needed, they were made before the unit was considered ready for shipment.

The enlisted men who made up the harbor patrol component were, for the most part, inexperienced in small craft. Therefore, the greatest part of the training at San Pedro was aimed at familiarizing the crews with small boats so that they would be able to operate and maintain them under difficult conditions in forward areas. Their training consisted of orientation, 45-foot picket boat characteristics, instruction by individual rates, fire fighting, recognition and lookout, first aid, damage control, military drill, and anti-aircraft firing. In the training afloat, they received instructions in boat handling, gunnery, piloting, communications, drills, upkeep, and coordinated drills.

The enemy's use of sneak craft and swimmers did not allow the harbor defense unit's job to end when ships crossed the defense lines safely and dropped their anchors inside the harbor. The anchorages had to be kept safe, and that was considered the job of the harbor patrol component. The picket boats, equipped with a two-way radio with HECP as well as special gear to combat sneak attack, acted as a second line of defense for shipping by constantly patrolling anchorage areas. Experience revealed that in some areas sneak craft did not always come from the entrance of the harbor but were often carried overland to some isolated inner-harbor beach area from where they would be launched.

Harbor patrol, in time of war, must always be suspicious of any form of debris seen floating in a harbor. A drifting wooden box may look very innocent to the average person, but harbor patrol crews would immediately suspect the box of hiding some type of sneak attacker. It is not the job of the crews to keep the harbor clean, but it is their job to make sure, through investigation, that the debris is nothing more than what appears on the surface. Enemy swimmers have found ordinary wooden boxes very helpful items for their missions.

By being trained and experienced in seamanship and in the special equipment supplied to handle sneak craft and by keeping a good lookout for any unusual activity on harbor shores and anchorages, the harbor patrol craft can perform its important job with little trouble and with high efficiency.

Section VI

SMOKE DEFENSES

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FOREWORD

SMOKE DEFENSES

In the war history of the United States there have been two very distinctive uses for smoke, one of them very dangerous, the other of outstanding service.

The dangerous smoke in warfare dates as far back as the invention of the steam engine. The coal burning ships, by belching their smoke into the skies, could never keep their position a complete secret from the enemy. All that the foe had to do was to keep his eyes on the skies and he would know that if anyone were around he would see their smoke. In those early days no sound equipment was needed. All that was needed to contact the enemy was a good lookout with at least one good eye.

In the days of the "coal burners," the ship that had the smoke was the ship likely to be sunk or put under attack.

Smoke in modern-day warfare, however, has changed, just as ships have changed. When one looks at the use of smoke in today's type of war, it is hard to believe that at one time it was considered dangerous. Smoke, today, is a defense, a tremendous aid in saving ships, their personnel and supplies. It is used as a cover, a blanket of camouflage, to completely hide ships, airfields, camp sites, and other such areas both ashore and afloat.

Throughout World War II the Bureau of Yards and Docks together with the Bureau of Ships conducted research on the use of smoke for defense purposes. The first application in its use was through smoke pots which were a part of the equipment that was sent ashore with the first waves of troops at Guadalcanal and North Africa. The use of these smoke pots showed that smoke had great possibilities for the future.

With each invasion, the engineers working with smoke learned something that would be of invaluable aid in future operations. Research kept going at full speed. Appreciations for the invaluable aid smoke offered in forward areas kept increasing.

From the smoke pots, the engineers went into another field, that of making smoke through generators. By this method, huge clouds could be made in short notice. By placing these generators on the stern of destroyers, DE's, and on down the line to LCI's, an entire harbor, cluttered with fleets of war and cargo vessels, could be covered in a very short time. By using generators ashore, an entire area could be covered just as easily and quickly.

The results of using these smoke generators proved that smoke constituted one of the most profitable means of harbor defenses that was in use. Excerpts from reports telling of such outstanding results in the field of operations are quoted in this section of the manual.

But making smoke in such a way that it proved effective is not as easy as some may think. It takes a complete understanding of atmospheric conditions and of the equipment itself.

The articles which are printed in this section about smoke are concerned with the operational part of smoke defenses—while the bibliography will guide the reader to publications where answers can be found on equipment and the more technical aspects of the subject.

Through concentrated study and a careful application of the tactics that are recommended by research and operational engineers, smoke can be one of the most complete harbor and shore defenses the Navy has at its disposal. With such an understanding, smoke can hide the target. But if the tactics are not used wisely and by trained personnel, smoke is very likely to return to the early days of warfare, with nothing being covered and with some good targets being made quite distinguishable.

PURPOSE AND SCOPE

In the course of World War II, particularly in the European theater, it was definitely established that smoke camouflage is a valuable form of protection for a wide variety of activities ranging from individual ships to large industrial urban areas. It is believed that the potential value and scope of smoke camouflage is even greater than is now realized and that the processes and equipment are more effective and economical of supplies than any that was available to the enemy for this purpose. No directives are contained herein regarding the method in which this equipment shall be used, but rather it is recommended that experiments be conducted in each area where equipment is available to determine the arrangement under which it will provide the maximum benefits, with particular emphasis on the coordination of the screening activities with the operation of aircraft and other activities. The information presented here will assist in planning the installations and operating the generating equipment.

GENERAL DISCUSSION AND TACTICAL CONSIDERATIONS

The principal features justifying the use of smoke as a measure for protective concealment are:

(*a*) The obscuration or distortion of the vital area by the screen makes precision bombing difficult, if not impossible, and forces attacking bombers to resort to area bombing, with a consequent reduction in the probability of effective hits.

(*b*) The screen prevents assessment by the enemy of any damage which may have been inflicted by an attack.

(*c*) Its use promotes a definite beneficial effect on the morale of civilian and other personnel not participating in active defense operations.

It must be realized, however, that the production of an effective screen is a problem requiring adequate equipment and personnel and careful planning and organization. A screen that is properly planned and executed may be an invaluable asset to the defense whereas a hastily improvised screen may well prove to be a liability.

Once the smoke has been released from the generators, its behavior is subject entirely to air currents. Time must be allowed for the smoke to be carried by the wind from the generators to cover the vital area before the arrival of enemy aircraft. The necessity of anticipating changes in the direction and velocity of the wind and in the tactical operations of the active defense system demands a close coordination of the smoke generating organization with the warning system, the local source of meteorological data, and operations headquarters.

Consideration must be given to the location of any active defense facilities whose operations are dependent upon direct vision so that the screen will not hamper their activities during an attack. The persistence of the screening material is of particular significance in this respect since the cloud may be of sufficient density to substantially reduce visibility several miles downwind from the generators.

The desirability of smoke camouflage, as opposed to structural camouflage such as nets and similar devices, varies according to the size and nature of the activities which are to be concealed. For most installations covering a comparatively small area, structural camouflage may be considered as a possible alternative to smoke, but for larger objectives the cost of structural camouflage increases and its effectiveness is reduced. In any case the objective should be toned down by plain color obscurative painting as whatever camouflage scheme is applied can be considered as complementary to this initial and basic tone-down measure.

Smoke under some conditions, particularly in daytime, is conspicuous from the air and its use indicates that there is something to conceal, whereas the existence of structural camouflage may remain unknown to the enemy. For this reason smoke should be used to screen only an objective whose general location is already known to the enemy or distinctive shore lines and landmarks which might otherwise be used as reference points for locating the objective. The use of a decoy screen to draw enemy attention and attack away from a well-concealed base may be found practicable under some circumstances.

The purpose of smoke screens before the extensive use of aircraft was to provide concealment from horizontal observation, for which a vertical screen or curtain was sufficient. Since concealment from aerial observation is generally the objective of the camouflage of shore activities, a horizontal screen or blanket also is necessary.

To achieve its purpose the blanket need not be as dense as would at first appear necessary. A cloud which appears too thin when observed vertically may afford sufficient obscurance when observed obliquely as from the bomb-aimer's angle—due to the increased number of particles encountered along the line of vision.

Black smoke and white smoke rely on different principles for their screening effect. Black smoke, composed principally of solid particles in suspension, absorbs light in its passage to the ground from the sky and on its return from the ground to the observer. Thus, the contrast of light and shade or between variously colored areas, which delineates specific objectives, is reduced. Complete obscurance is achieved only by a cloud of such density of particles that there remain no uninterrupted passages through which light can penetrate.

While smoke or fog reduces definitive contrast on the ground not only by reducing the intensity of light reaching the ground but also by reflection and scattering of light from the source by the minute drops of moisture of which the fog is composed. The greater part of the screening value, however, is derived from the veiling glare interposed between the observer and the objective by the reflected and scattered light rays. The brillance of this glare reduces the apparent contrast defining objects on the ground and so affords a practical screen before complete coverage is attained.

Due to the large amount of light provided by the sun during the daylight hours, the contribution of the glare from the white smoke enables it to obscure objectives at much lower concentrations than would be required if black smoke were used. Under normal conditions the quantity of black smoke required by day for effective area screening is so large as to render its use impractical.

As the illumination is decreased, so is the disparsity in the efficiency of white and dark smokes. Although sufficient data has not been accumulated to definitely establish their relative merits throughout the range of illumination, it is possible that black smoke may become superior to white smoke at some low point in the range since, with the reduction of illumination level, the relative effect of reflection and scattering of light decreases, while that of absorption increases. Even at night, however, brilliant illumination is to be anticipated, since it is practically certain that flares will be used in a night attack.

TYPES OF FOG GENERATORS FOR USE ON LAND

Artificial oil fog has been adopted as a screening medium for naval shore activities because its general characteristics are superior to those of other screening agents. The size of the particles of which the fog is composed has been found to be a critical factor in the screening efficiency of the resultant cloud and is determined by the temperature and velocity at which the vapor is discharged—higher velocities producing smaller particles. The particles are of correct size (approximately 0.6 microns in diameter) when the sun, as seen through the cloud, appears to be slightly orange in color.

In the development of fog generating equipment for distribution to the field, the principal considerations are mobility (or portability) and simplicity of mechanical design and operation. These characteristics were not primary considerations in the design of the generator designated Utility 20, Design 1, Modification 0 (Army designation: Generator, Smoke, Mechanical, M–1 (100 gallon), since it was intended to meet certain specific requirements of the Chemical Warfare Service, U. S. Army, and be carried in the U. S. Army standard M–7 ordnance trailer. In subsequent designs, however, weight has been held down to a practical minimum, the mechanical arrangement is reduced to its simplest possible form, and the units are mounted on trailers with standard towing hitches so that they may be moved easily and rapidly as occasion demands. The generators are so mounted on these trailers that they may be easily detached and used as skid units, to be carried or dragged to various positions or established in permanent emplacements.

The equipment developed for generating artificial fog is of two types—boiler type and exhaust type.

(a) In the boiler type generator, oil—together with a certain amount (usually 4–7% of water—is vaporized in the coils of an oil-fired boiler and discharged through a set of nozzles into the air, where it condenses to form an oil fog. The addition of water to the oil minimizes the tendency of the oil to break down and form coke on the inside of the coils and also, as steam, precludes the possibility of flaring at the nozzles.

(*b*) In the exhaust type fog generator, the fog oil is sprayed from pressure nozzles into a chamber through which pass the hot gases resulting from the combustion of a fuel. The oil is vaporized by the heat of these gases and discharged with them through one or more discharge orifices into the air, where the vapor condenses to produce a cloud of composition identical with that generated by the boiler type units.

FUELS FOR FOG GENERATORS

It is essential that only clean liquids be put into the tanks of the generators. The following precautions should always be taken:

(*a*) Keep all containers carefully covered.

(b) Wipe dirt from around the bung of a barrel before opening it.

(*c*) Avoid pumping directly off the bottom of any container where dirt is liable to collect.

(*d*) Never use a dirty funnel, pipe, or container.

(*e*) Make certain that no water becomes mixed with the fog oil, fuel oil, or gasoline.

The physical qualities of an artificial fog are dependent upon the material of which it is composed. In the course of early investigations it appeared that oils derived from petroleum sources would, in general, be the most satisfactory material for the purpose because of their relatively low cost, wide availability, and their high boiling temperatures. All other factors remaining the same, the persistence values of fogs are substantially proportional to the boiling temperatures of the materials of which they are produced. Fogs produced from oils are very persistent, as well as nontoxic, nonirritant, and noncorrosive. The use of oils whose boiling temperatures at 10 mm. pressure are above 610° F. is considered impractical because some constituents will "crack" before being vaporized and will therefore be wasted. The maximum limits on the values for the neutralization number and carbon residue are included in order to prolong the operating life of the coils in boiler type generators.

Listed in Table I are a number of oils normally stored at naval activities which are considered suitable for use as fog oils in either exhaust type or boiler type generators. Fog oils FO–1 are for use when the air temperature is above 0° F. and fog oils FO–2 when the air temperature is below 0° F. With whatever oil is selected, satisfactory results will only be assured if a diluent is added in cold weather to reduce the viscosity of the oil, permitting it to flow freely. The following table shows the mixtures recommended for various ranges of air temperature.

Temperature range	Fog oil base	Diluent
Above 60° F	100% FO–1	None.
40 to 60° F	90% FO–1	10% Burner Fuel A.
0 to 40° F	75% FO–1	25% Burner Fuel A.
—15 to 40° F	100% FO–2	None.
—40 to 15° F	90% FO–2	10% Burner Fuel B.

For the protection of tanks, lines, valves, and pumps and to maintain the generators in constant readiness for operation in cold climates, denatured alcohol should be mixed with the water as an anti-freeze agent. Listed below are the freezing temperatures of various solutions of denatured alcohol and water. Slightly higher proportions of alcohol must be added to prevent freezing at these temperatures.

Freezing temperature	Water	Alcohol
	Percent	*Percent*
20° F	85	15
10° F	75	25
0° F	65	35
—10° F	60	40
—20° F	55	45
—30° F	45	55
—40° F	40	60

TABLE I—*Navy Symbol Oils Suitable for Use as Fog Oil*

Navy symbol	Supplier	Pour point	Suitable for use as—	
1047	Texas Company		FO–1	
2075	Atlantic Refining Co	—25°F.	FO–1	FO–2
2075	Calumet Refining Co	—35	FO–1	FO–2
2075	Socony-Vacuum Oil Co	—35		FO–2
2075	Texas Company	—30		FO–2
2075	Tidewater-Associated Oil Co	—30		FO–2
2190	Calumet Refining Co	—20	FO–1	FO–2
2190	Sinclair Refining Co		FO–1	
2190	Socony-Vacuum Oil Co		FO–1	
2190	Texas Company	—20	FO–1	FO–2
2190	Tidewater-Associated Oil Co		FO–1	

NOTE: Each oil listed as suitable for FO–2 should be used only when the minimum air temperature encountered is higher than its pour point.

ORGANIZATION OF PERSONNEL

The importance of adequate training for the planning personnel and for the operating and maintenance crews cannot be too strongly emphasized. Although the personnel assigned for this work will normally have other regularly assigned duties, drills and practice with the equipment should be held at sufficiently frequent intervals to insure thorough instruction in the execution of specific duties and efficient coordination of the entire force whenever the necessity for generating screens should arise. The principle functions of the personnel organization should include:

(*a*) Planning and control
(*b*) Movement and supply of equipment
(*c*) Operation of generators
(*d*) Maintenance

All activities of the screening organization should be planned and directed from a control and communication center, from which close contact may be maintained with base headquarters, the local source of meteorological data, and the warning system. The location of generators should be planned and their movement directed from this control center in accordance with the weather forecasts and the military operations in the area, so that the equipment will at all times be in the most advantageous position to put up an effective screen as soon as possible after receipt of a warning signal. To insure that the screen will remain effective despite variations in the conditions under which it is produced, close liaison during screening operations is important so that the generator layout

may be promptly revised—and the generators moved accordingly—in coordination with changes in the other defense plans or in the weather conditions.

The personnel and facilities required for the movement of generating equipment and supplies are almost entirely determined by the nature of the terrain in which the generators must be located. If conditions are favorable, the generators can be towed to their respective positions and the necessary fuels delivered in drums by truck or pumped directly into the tanks from tank trucks. Where the terrain is impassable for trucks or other vehicles, however, the generators must be dragged or carried to their sites and the fuels and supplies must be rolled or carried in.

All the personnel designated for the operation of the generators should be completely familiar with the operation and general characteristics of the units to which they are assigned. In addition to starting it as rapidly as possible on receipt of orders, each operator should remain in constant attendance with the generator in his charge until it is shut down.

In the force assigned to the maintenance of the generating equipment there should be at least one qualified mechanic who is familiar with the theory and construction—as well as the operation—of fog generators. Under his supervision each generator should be run for a brief period at least once each week for a check on mechanical adjustments, to insure that the units will operate efficiently whenever the need may arise.

AREA SMOKE SCREEN IN HARBOR DEFENSE

A properly executed smoke screen has been found most effective for the protection of anchored shipping against dawn, dusk, and night air attack. Reports from Pacific operations in the latter months of the war revealed that smoke was being used in continuously increasing amounts and with excellent results to cover the transport areas during air attack. One task force commander, in recommending that ships be dispersed as little as practicable in the transport area in order to obtain maximum protection from an area smoke screen. confirmed the fact that damage sustained by ships from enemy air attack while under the protection of an area smoke screen was of a very minor nature.

Not until the latter part of 1944 did the need for such night protection become apparent. It was no longer possible to neutralize completely all enemy aircraft operations capable of supporting the enemy ground forces as was so effectively done in the earlier stages of our westward movement in the Pacific. Changing conditions lent themselves more favorably to enemy aerial action during the operations. Enemy aircraft were no longer completely neutralized. Enemy airfields were well within flying range. The location of Allied attacking forces and vessels were known to the enemy.

For combating enemy air attacks in daylight, fighter air cover and ample antiaircraft appeared capable of coping with such attacks as may have developed. Night air attacks, however, caused grave concern due to the lack of night fighter protection and the reduced efficiency of AA gunfire.

Two courses of action could be taken by ships in countering night air attack—get underway and take evasive action or remain anchored and use smoke. Getting underway involved maneuvering in limited or confined areas and there was always the possibility of encountering mines in unswept waters. By remaining anchored and using smoke, unloading operations, though reduced in efficiency, could be continued.

With the available types or radar-controlled night fighters and radar-controlled AA fire, protective measures for shipping and harbor installations against determined night air attack should include the use of smoke screens. Operations at Saipan, Leyte and Anzio, where practically complete protection of shipping was afforded by smoke, substantiated the merit of using smoke.

The advantages and disadvantages of dawn, dusk and night smoke screens should be realized in order that an over-all picture of their effectiveness may be obtained.

The advantages which have been recognized thus far, as resulting from the use of smoke, are as follows:

1. Airborne torpedo attacks, the most destructive type against anchored shipping, are virtually eliminated. Due to the nature of the approach required, it becomes practically impossible for a torpedo plane to make a run on a target in a smoke screen.
2. Other types of enemy air attacks are greatly reduced in efficiency, even though flares are used by the enemy planes. With no specific targets visible, level or dive type precision bombing cannot be used and "area" bombing must be resorted to. This latter type is notably ineffective against shipping and much less destructive to shore facilities because of the lower probability of effective hits.
3. Unloading operations may be continued without lengthy interruption, resulting ultimately in the ships leaving the combat area at an earlier date.

The disadvantages resulting from the use of smoke are as follows:

1. Visually controlled antiaircraft fire cannot be used

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under a smoke screen. Experience in general, however, has shown that this type of fire is ineffective at night. Some task force commanders engaged in Pacific operations abandoned the use of night AA fire from the transports when a smoke screen was used and instead called upon the screening vessels, DD's etc., to provide such fire when necessary. Smoke will not interfere with the operation of radar-controlled AA fire.

2. Searchlights located under smoke screens will be ineffective.

3. Aircraft operations will be disrupted should smoke cover an airfield from which operations are necessary during an attack.

A brief description follows of the layout, operation, and organization of an effective smoke plan for the protection of shipping and harbor facilities against night air attack. For descriptive purposes the location is imaginary, but it is based on the plan used in a Pacific operation.

There are three main sources from which smoke is obtained:

1. From ships anchored in the harbor or area.
2. From patrolling fleet smoke picket boats.
3. From a shore-based units using fixed land and water-borne equipment as may be necessary.

The methods vary by which each of these sources employs their smoke generators. Each large transport type ship used in Amphibious Operations (APA, AKA, AGC, LSV, LSD) usually have two mechanical smoke generators installed on deck and one or two generators for use in ship's boats (LCVP's, etc.). In addition, floating chemical smoke pots are carried.

On prearranged signal the generators aboard ship are started and one or two of the generator-equipped boats proceed upwind of the ship to a predetermined location. Smoke is made on the way to and while operating at this position until the alert is over. The task of these boats is to aid in the covering up of their own ship, and it may be necessary for their operating position to be changed as shifts in wind direction occur.

The chemical floating smoke pots are dropped in the water as required to aid in the rapid development of the screen and to fill in such holes as may develop. It should be borne in mind that the HC type chemical smoke, produced by these smoke pots, is toxic in high concentrations. Personnel exposed to high concentrations should wear standard gas masks.

Patrolling fleet smoke picket boats may or may not be used. They usually consist of SC's, YMS's, LCI's, etc., equipped with mechanical smoke generators which patrol on the outer edges of the anchorage, augmenting the smoke produced by the ships and covering up the ships on the upwind side of the anchorage. If sufficient smoke is produced by the shore-based unit, whether the smoke generators be water-borne in small boats or in fixed land positions, the use of fleet smoke pickets may be unnecessary.

The shore-based smoke screen unit should be sited in general, as shown in the diagram. Its purpose is (a) to augment the ship smoke, insuring complete coverage of shipping, (b) to cover up harbor facilities and shore installations, (c) to produce a large smoke cloud over a wide area, thus reducing the probability of effective hits by "area" bombing, and (d) to cover up reference points so as to decrease the possibility of enemy planes bombing by instruments.

Several factors, worthy of mention, should be considered when planning the location of these various smoke sources.

For equipment normally assigned ships:

1. The smoke boats (LCVP's, etc.) when operating so as to provide smoke protection for a certain ship frequently operate too close to that particular ship. When this is done the dense cloud of smoke is not given sufficient time to spread in its travel and results in only partial coverage being effected.

2. In order that sufficient smoke may be provided for ships located at the upwind end of the smoked area, smoke picket boats should operate well to the windward. Failure to do this will result in gaps being formed in the smoke cloud through which ships will be plainly visible.

3. Anchoring ships as closely together as practicable will enable the smoke generating equipment to be used with greatest effectiveness.

For equipment normally based ashore:

1. Smoke generators on land should be placed in foxholes in fixed positions so the desired area can be screened regardless of wind direction. "Prevailing" wind directions should not be relied on as the prevailing wind may not exist at the particular moment of attack.

2. As it is impractical, if not impossible, to move smoke generators on land at night, sufficient smoke equipment should be provided in fixed positions for any wind direction. Depending upon conditions of road, transport facilities and enemy action, it may be practical, however, to move personnel rapidly, thus reducing the number of men required.

3. The generators should be located at a sufficient distance upwind to enable the smoke from the individual generators to merge into a blanket screen before reaching the area to be covered.

4. Areas and wind directions that cannot be successfully covered from land-based equipment can be taken care of by the shore-based smoke screen unit by temporarily placing smoke generators in small boats (LCVP's, LCM's) each night shortly before dusk. Such boats are usually available during the hours of darkness from the local boat pool, even in the most

advanced areas. With the new lightweight smoke generators, such equipment can be readily removed so that the boats can be used for their normal function of unloading ships in the daytime.

Success of smoke operations is greatest when complete coverage is obtained. As the number of smoke sources available and the manner in which they are employed will vary with each smoke operation, an understanding of the relative merit of each type of smoke source as well as its proper application will contribute materially to the resulting effectiveness of the overall screen. In addition, a reduction of waste of the usually limited supply of smoke material will result from the proper combination, distribution, and operation of these smoke sources. Efforts may be made to "stretch" existing supplies by using insufficient amounts of smoke material. Emphasis, however, must be placed on the necessity for producing a maximum amount of smoke when operating so that complete and effective coverage of the target area will be obtained. Routine morning and evening twilight smoke screens have been used for protection against undetected attacks where surrounding terrain conditions may make radar detection of low-flying enemy aircraft difficult. This method was very effectively employed in Pacific operations where considerable enemy aircraft activity was experienced in the dawn and twilight hours.

The success experienced by forces which found smoke to be a most effective protective measure was reflected twofold—in the increased demands for smoke equipment from those without it and for increased allowance from those already equipped.

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LARGE AND SMALL TARGETS RECEIVE SMOKE SCREENING

"The benefits gained by the extensive use of smoke in the transport area are believed to be the outstanding lesson learned in this operation." "The use of smoke in the transport area was of inestimable value." These and similar comments were repeated many times in reports concerning the use of smoke in amphibious operation.

A Task Force Commander reported that "Success in the use of smoke depends upon the simplicity of the plan, the flexibility of the plan, reasonably favorable weather conditions, and previous proper indoctrination of all ships." The factors essential for achieving a successful smoke screen are recognized as planning, training, and the weather.

As smoke screens may be used in a wide variety of circumstances, this article will discuss area screens which are generated over stationary targets on land and water. Depending upon the amount of equipment available and the kind of application desired, screens may be divided into those covering large areas completely or those covering small individual targets, called spot screens. Each of these has its particular application. Large area screens can be used for covering anchorages, transport areas, airfields, and supply dumps while spot screens cover individual targets such as single ships or radar installations.

Smoke once generated and released into the air becomes airborne, and its movement thereafter depends upon the atmospheric conditions prevailing at that time. Under such conditions it is apparent that if a successful screen is to be obtained one must understand not only the relative merits of the equipment and how it is to be used but should also have an understanding of how smoke behaves under various atmospheric conditions.

The factors which influence the characteristic of a smoke screen are listed as the stability of the air, wind velocity, rate of smoke production, type of terrain, and the kind of smoke. These factors vary in degrees of importance, but all have a particular significance upon the resultant screen.

Stability of the air is a factor of major importance in the behavior of smoke. For this discussion, stability is defined as a condition established by the variation in temperature between different levels of air or the temperature gradient of the air. In general, stable air conditions are obtained when the air temperature is greater than that of the water or ground, and unstable conditions are discovered when the air is colder than the water or ground immediately below it. As the convective pattern of the air is governed by stability, so is the horizontal and vertical diffusion of the smoke. The spread and rise of screens in stable air is generally

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gradual and uniform. In unstable air, however, the spread and rise of screens is very erratic. Smoke is distorted vertically in pillars and hollows. Irregular lateral distortion also occurs at the same time.

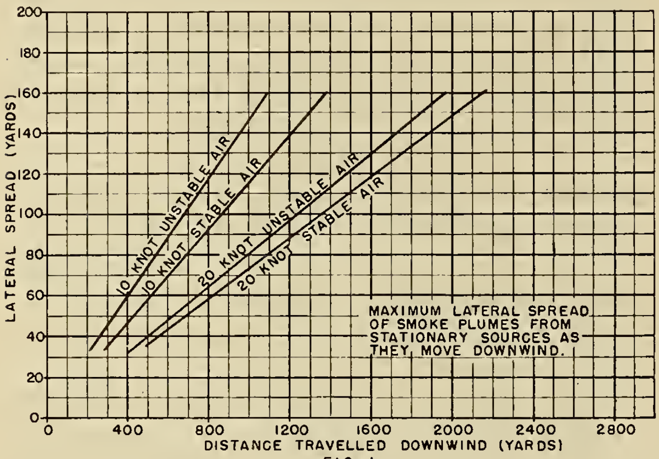


FIG I

Because stability is governed by the temperature gradient which exists at any location, it is possible for stable and unstable air to be obtained in areas adjacent to each other. This is a common occurence along shorelines on sunny days when air which has blown over water for some distance blows over land which has been heated by the sun. The variation in lateral spread of smoke plumes from stationary sources in stable and unstable air as they move downwind are given graphically in Figure 1. The persistence or effective life of a smoke screen is affected also by the degree of stability. In unstable air, thin spots and holes develop in the screen which are due primarily to the action of convective currents. In general, the tendency for the screen to become "spotty" increases as the unstability becomes greater. In stable air, uniform thinning of the screen takes place as it moves farther from the source.

The results obtained from many tests have established the fact that a certain minimum concentration of smoke is required in order to obtain complete screening. This concentration is not constant but varies, depending upon the amount of light and the brightness of the target. If the smoke concentration is to be kept above this minimum, the amount of smoke generated per unit of source length must be varied with wind velocity. The amount of smoke required to obtain complete obscurance under stable and unstable conditions with wind of the same velocity apparently varies with the degree of unstability. This is graphically illustrated by Figure 2 in which the minimum number of smoke generators required per mile of front is given in order to obtain a smoke cloud of density sufficient to render overhead observation ineffective in daylight hours. The values in this graph may be reduced by approximately 40 to 50 percent for use after dark. Wind velocity also has an effect upon the lateral spread of the smoke as can be seen in Figure 1. The spread of a smoke cloud is considerably greater in a wind of 10 knots than in a wind of 20 knots after a given distance of travel downwind. If, however, the age of the screen is used as a basis instead of the distance travelled downwind, lateral spread will be approximately the same in wind of 10 or 20 knots.

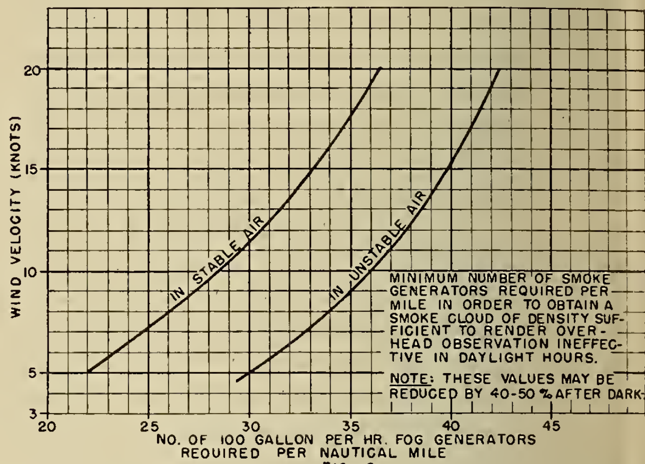


FIG 2

The rate of smoke production is important because the smoke concentration is dependent upon it. As the wind velocity and stability conditions are subject to continual change, it may be necessary to vary the rate of smoke production in different screening operations. This is accomplished by varying the number of smoke generators per given length of source line. Present types of smoke generators do not permit individual variation in operation capacity during their operation. In this connection, the importance of having an adequate concentration of smoke is emphasized.

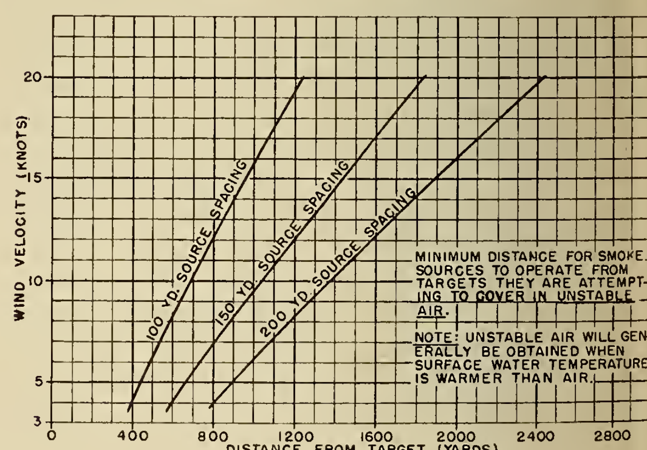


FIG. 3A

The type of terrain over which a smoke cloud is moving also has an influence upon its behavior. The normal flow of air, as of any other fluid, tends to follow the line of least friction or opposition. Topographical details are essentially resistance factors, which tend to retard or change the direction in movement of a smoke

cloud. Heavily wooded areas offer considerable resistance to air flow. If a wooded area is wide or if an unstable air condition prevails, the smoke will tend to rise and pass over the trees. In a stable air condition the smoke will tend to flow to either side of the area, but in a large area it will move through. Wooded areas also cause a reduction in the velocity of the wind as it moves through them. In general, as the terrain features become rougher the turbulence of the air becomes greater. Increasing turbulence causes a corresponding increase in the unstability of the air. Least turbulence is encountered over water or on fields covered by snow.

Should occasions arise when chemical smokes such as FS, FM, HC, or WP are used instead of oil fog for area screening purposes, material requirements and the method of application will vary due to their different rates of smoke production and screening efficiencies. These agents are primarily for tactical use in active combat. On occasions when they have been used for screens similar to those used for harbor defense purposes, reports do not recommend their extensive use because of the irritating and nauseating effect upon personnel.

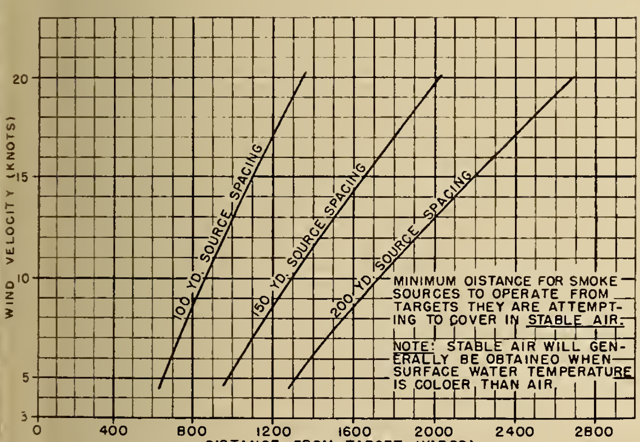


FIG. 3B

The most important element in an area screening operation is for the generators to be located so that a complete blanketing screen is obtained before it passes over the target. The two smoke screens used for tactical purposes are large area screens and spot screens. Plans should be made for the distribution and operation of equipment under stable and unstable air conditions for each of these groups. Because variations in the location and type of each target may vary, each installation will generally be "tailor made" to meet the particular screening requirements which exist. In order to fulfill these requirements, it may be necessary to locate the smoke generators on land or on watr.

When generators are to be operated on water they will usually be placed in small boats, barges, or in craft designated as smoke pickets. As sources of this type are capable of movement, control of the screen is facilitated when changing conditions indicate the desirability of shifting the location of the smoke-generating sources. When generators are located on land, it generally will be found desirable to locate them in fixed positions because of difficulties experienced in moving them rapidly from one place to another.

The most important factors to be considered when placing generators on water or on land are the distance upwind that they operate from the target, the spacing between each source, and the amount of smoke generated at each source. Every effort should be made to have the sources spaced equidistant from each other. If this is not done, gaps or openings will develop in the screen and may reduce the effectiveness.

When generators are located ashore in stationary positions it is advisable that sites be selected which will enable smoke coverage being obtained under the most critical conditions. Generally this will happen when winds of high velocity and stable air conditions prevail.

The graphs in Figures 3A and 3B illustrate how the distance of the sources from the target varies with respect to wind velocity when they are located on water. When generators are located on land, these distances in the graphs will be decreased. It will also be noted from these graphs that sources spaced 100 yards apart can be placed much closer to the target than sources at a greater distance.

In planning spot screens where very limited numbers of generators are available, the necessity of determining how equipment is to be used is of paramount importance. With few sources and limited quantities of smoke, it is imperative that generators be located to allow proper spacing and distance from the target so that most efficient use can be made of the equipment. Figures 1, 2, and 3 can be used as guides in planning any such operation.

Under some conditions the use of moving sources is desirable. Such a case may arise when stable air and low wind velocities are encountered. In this event, the use of a small boat operating in a circle at considerable speed is desirable. This will enable the smoke cloud to be spread much wider initially, thus making more efficient use of the smoke producing materials. It also will allow the smoke source to operate closer to the target, thus reducing the time required for the smoke to cover the target. The most important factor in an operation of this type is for the boat speed to be considerably greater than that of the wind.

In view of the necessity of having coordinated action between the relatively large number of individual sources involved in a smoke screening operation, it is apparent that adequate methods of communication be provided. Due to the short notice usually obtained prior

to an air attack, radio communication is essential if a successful screen is to be had. Every effort should be made to have adequate radio channels assigned to handle the traffic. Reports from some smoke operations stated that when it became necessary to control small boats major difficulties were experienced because of the excessive volume of communication traffic on the assigned frequency.

Personnel involved in the over-all operation of the smoke-generating equipment constitute another element which has a direct effect upon the success of the screening operation. Smoke generators are mechanical machines. Their operation is not difficult but should be understood. Personnel can be trained to operate them with only a few hours instruction.

Experience obtained from the intensified daily use of smoke in most operations reveals that:

1. Smoke is recognized as a defensive measure of inestimable value.

2. The maintenance and repair of smoke generators is the greatest single obstacle encountered in actual operation.

3. It is necessary to have trained personnel available who are capable of repairing all the various generator types.

4. It is very important to have personnel assigned to perform all specialized duties required in an operation. In connection with the use of smoke ashore, one recommendation is quoted: "If smoke is to be made on beaches and diligently attended to, a special detail should be assigned to place and operate the generators."

Section VII

NETS AND BOOMS

Section VII—NET AND BOOM DEFENSES

FOREWORD

NET AND BOOM DEFENSES

The standard handbook on net and boom defenses, as regards history, design, installation, and maintenance, is the BuOrd publication, Ordnance Pamphlet 636A. For that reason this pamphlet is included as a part of the Harbor Defense Library, and covers most of the necessary information on nets and booms. In order to insure that the most recent information is included herein, some comments concerning the latest developments during World War II, including the very important subject of AKN–AN operations, are published in this Net and Boom section of the Harbor Defense manual. All subjects not printed here can be found in the BuOrd pamphlet.

THE AKN–AN TEAM

THE AKN CLASS VESSELS

In 1943 three EC–2 hulls—Liberty Ships—were allocated for conversion to the Navy's first net cargo vessels, or AKN's. They were the *Indus* (AKN 1), *Sagittarius* (AKN 2), and *Tuscana* (AKN 3). At the same time the *Keokuk,* once designated as a net layer, and later serving as a minelayer, was converted to be the AKN 4.

This conversion was dictated by the requirements of the Pacific war. During the early stages all net defenses were carried out in cargo ships, unloaded on the beach with handling equipment, and slowly and painfully assembled on the beaches, dragged into the water, and installed in place. While the method itself was a time-consuming one, it was aggravated by the fact that the material was always delayed in delivery and usually arrived separately from both the handling equipment and the personnel. The place of assembly was apt to be a sea of mud, and the water approaches too shallow for close-in operation of net layers. Consequently, weeks were required for the laying of as much as one mile of torpedo net, and on some occasions the need for the defense had largely passed by the time it was completed.

It was evident that the net cargo ships could readily solve such problems. Of the types of torpedo net current at the time they were commissioned, T–5 and T–6, which used a large quantity of the bulky Mk 2 buoys, the vessels were estimated to be able to carry 1½ miles. With the development of Type T–8, which eliminated two-thirds of the large buoys, and T–10, a similar design using 50-foot net panels, it was ultimately found that up to 7600 yards of net defense could be loaded.

The *Keokuk* was not intended for the carrying of the heavy torpedo net. In her troughs, instead, were laid ten 1,000-foot sections of the newly developed light torpedo net (Type LISP–2) for very rapid laying during assault phases of invasions. This light net was very successfully laid at Saipan, Kossol Passage, and Kerama Retto. At the latter place, the *Salem* (CM 11) also performed similar duties. They afforded effective temporary protection to vessels of the assaulting force during operations.

AKN OPERATIONS

The operation of the large AKN's, which were soon joined by the ex-merchant ship S. S. *Matthew Lyon,* renamed *Zebra* (AKN 5), became standardized. Material stowed above decks first was removed to the extent necessary to permit net assembly; normally this had to be placed ashore. Then the various components of the net line were brought out of the holds and placed in their locations in an assembly line. Spherical buoys came from No. 1 hold; nets from No. 2; jackstays and fittings from No. 3, and possibly some extra net; anchors and clumps from No. 4; and chain from No. 5. Nets were spread out, and the flotation buoys and fittings attached. As the panels of net were married, the sections streamed over the side, where they were secured or were towed to the net line. Sections 800 feet long were assembled as a standard practice, and on some occasions a continuous line of 1600 feet was launched over the sides. Aft, the anchors and chain were hoisted over the side to a waiting lighter or dressed directly as made-up moorings on the horns of net layers lying alongside.

Two methods were employed in installing the net so assembled, and both will be outlined here.

In the first, the moorings were layed before the nets were buttoned in. Net layers received the material, steamed to the point of installation, and laid down the

anchors and chain where the navigator and his party had laid marker buoys. These markers, of course, had to be accurately placed, and considerable work was involved with sextant and distance line. After the moorings were in place, the assembled net was towed into position and secured in its place.

In the second method, one mooring was laid. A layer or tug then towed the first section of net into position, and secured one end to the mooring. Another vessel held the "loose" end, while net layers steamed up and added a mooring, in its seaward and harborside portions, to that end and thus secured it in place. The ensuing net section was then brought up, connected, and held by its end as was the previous one until the mooring was added. The operation was continued until the net line was completed. (In some cases the "loose" end of the net had only one side of the mooring attached to it previous to the connection of the following section, which facilitated the latter operation.) This method is called by some the "Progressive Method," a name given it by the *Tuscana*.

Both methods had advantages. The first, after final adjustment of moorings, developed a fine straight line of defense, with proper amounts of catenary between moorings. On the other hand, it was slow, relatively inefficient with regard to utilization of vessels, and required much preliminary survey work. The "Progressive Method" was efficient and fast, did away with many overlaps, and, as it simply built as it went, required little plotting and marking. It required, however, experience and good seamanship to obtain the best results, and to avoid zigzag effects and undesirably taut lines of net. Because of its speed and simplicity, this method was generally preferred throughout the Pacific, and is now almost universally considered the better.

The use of AKN's to carry and assemble nets afloat in this fashion made possible defenses at many harbors where they would otherwise have been impracticable. They installed nets at Kwajalein and Majuro, at Eniwetok and Saipan, at Tinian, Guam and Iwo Jima. In the Southwest Pacific they put in nets at Manus, Mios Woendi, Samar, and Subic Bay in the Philippines. With each operation the AKN–AN combination worked closer to D–Day, and at Kerama Retto in the Okinawa Gunto the *Keokuk* and *Salem* and attendant net layers laid 27,000 feet of light torpedo net (LISP–2) at the entrances to the harbor to provide a haven for battle-damaged vessels engaged in the assault of Okinawa proper. Subsequently the *Sagittarius* and *Tuscana* assembled the heavier type torpedo net laid in Buckner Bay.

PONTOON DIESEL TUGS, YTL–632 CLASS

An account of AKN–AN operations would be incomplete without mention of the YTL–632 class portable diesel pontoon tug especially designed and procured for AKN operation. Requested early in the development of AKN's, it was finally produced by the Bureau of Ships near the conclusion of the war, and saw just sufficient service to demonstrate its great value. There were eight in the class. They developed fifteen to nineteen thousand pounds' pull, weighed forty tons, and were used for towing net sections from the AKN's (which carried them) to the point at which nets were being installed. In so doing they released their number of AN's, which could then be assigned to other net duties. Their great power permitted them to lay two long sections of net as fast as the net layers could pull them, while their maneuverability permitted them to bring net alongside the AN's with a minimum of difficulty. In addition, they could lay net moorings in water too shallow for the net layers.

SPEED OF AKN–AN OPERATIONS

It is difficult to set forth a definite rate of speed at which AKN–AN standard torpedo net laying operations may be expected to progress. Such a rate depends greatly upon the sea and weather conditions, the climate, the experience of the vessels participating and their numbers, and the amount of interference which is to be expected from various sources. AKN's have on several occasions assembled torpedo net at the rate of one mile in four days, and at one time it was installed at this speed, using three net tenders. Such high speed, however, cannot be counted upon and may actually be the cause of assembly work that is less thorough than desirable. It is well not to expect that standard torpedo net will be installed at better than one mile per week, using two or three AN's and one or two pontoon diesel tugs per AKN.

Light torpedo net (LISP–2) reached a high rate of speed in laying during World War II. Ten thousand feet of protection were laid in periods of between one and two days, and in one exceptional occasion, this amount was put down by USS *Keokuk* in three and one-half hours, not counting time for brail cutting. It is to be expected that this light net, or its successor, may continue to be laid in times approximating one day.

BOAT BOOM EXPERIMENTS

While the standard motorboat boom was, and is, the line of unwieldy baulks, it had been assumed that an effective boom could be rigged by installing starcutters in the upper jackstay of standard net defenses. Japanese use, in 1945, of explosive motorboats and the capture of Italian explosive boats led to experiments to discover the truth of this belief.

It was found, during tests at Melville and Tiburon, that the Italian craft, with its retractible screw, could be made to jump almost any floated defense, while suf-

fering some damage to its hull. The Japanese craft was stopped by standard torpedo net with surface protection, and by the similar B–9 boom. It might, however, have been adapted to clear these defenses by adding a skeg and increasing the angle between the bow and the perpendicular.

THE DEEP SUBMARINE NET

During the period of use of Type LSI–2 net it had been assumed that this net could be suspended to a depth of 150 feet, or three panels deep. In actuality this had not been tried, and the few instances of its use had been in comparatively shallow water. Moreover, the indicator feature was not necessarily embodied, since the flares were short-lived, making the net a temporary defense, and this design was considered to be sufficient hazard to submarines without them.

In May of 1945 CinCPac requested a net similar to LSI–2 which could be suspended to the ocean bottom in 300 feet of water. The purpose of this net was to stop motorboats, surface-running torpedoes, and various underwater sneak craft. No indicator feature was desired. By combining materials from several types of net, BuOrd developed a design which, in experimental laying, showed sufficient strength for the conditions with which it was expected to contend. From the flotation buoys of heavy torpedo net was hung a short length of light torpedo net, Mk 3, such as was used in LISP–2 net for surface protection against suicide craft and swimmers. To the bottom of this was attached a special double jackstay, and the light submarine net was, in turn, clipped to the jackstay. The net itself was woven in fifty-foot increments to the required depth on the weaving slab at the Naval Net Depot, Tiburon, in accordance with the charted depths at the location for which the defense was planned.

In order to make certain that the AKN launching of such a bulky design was practicable, the *Zebra* (AKN 5) was detailed, along with several net layers (AN's), to conduct tests simulating service conditions. The net was brailed and tied into compact bales at the net depot and loaded on board the *Zebra* together with its flotation and moorings. Then the trials were carried out, using the full 300-foot depth net. It was successfully assembled and launched from the *Zebra*, and installed by the AN's. This demonstration was considered to have proved its practicability. Service use of this deep net was, however, prevented by the conclusion of the war.

Section VIII

SNEAK CRAFT

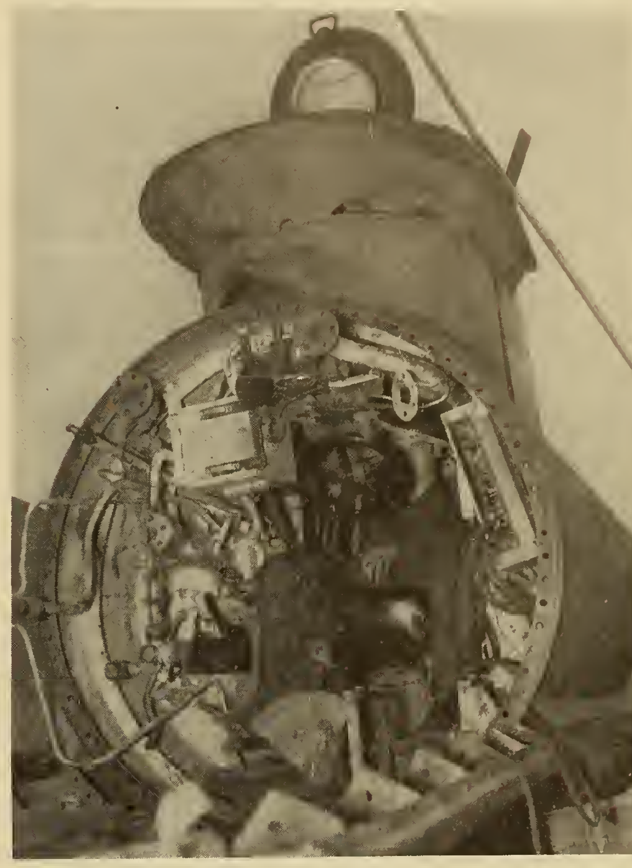
Section VIII—SNEAK CRAFT

GERMAN SMALL FIGHTING UNITS

Vice Admiral Heye, (K.d.K.), who was in charge of small battle units for the German Navy, was interviewed shortly after Germany's capitulation by an Allied representative on his work with the German Navy. The report which will be of particular interest to harbor defense personnel because of its relationship with one of Germany's most successful weapons, the small fighting units.

Given by Vice Admiral Heye 22d May 1945

The supposition for the origin of small fighting units was given by the military situation prevailing at the beginning of 1944 when it became necessary to construct arms against the invasion with the least possible delay, considering, however, the continually sinking capacity of the Germany armaments industry due to air bombardments on industrial factories and on railroads. These circumstances prevented the development of complicated and costly vessels which would also imply a longer training period as time premitted. In consequence, fighting units had to be constructed with a view to make use of existing technical components assemblage of which could be effected at small and smallest dockyards.



This is an inside view of *Seehund,* showing the operator at his controls.

The German *Seehund* is a two-man midget submarine, 39 feet long, and can carry two externally mounted 21-inch electric torpedoes or a number of mines. Maximum speed is from 6 to 8 knots surfaced and from 3 to 6 knots submerged. With a range of approximately 275 miles and at approximately 50 miles submerged at a speed of 3 or 4 knots, the Seehund is the best designed and best built midget U-boat encountered during the war.

The tactical plan was to attack the enemy with a great number of various types of small fighting units at the very moment of his landing operations. The simultaneous attack by the greatest possible number of different units would divert the enemy's defense and force the way into the landing fleet itself for a great number of fighting units. After the successful operation of one type, new ones would be in readiness to take a new full advantage of the moment of surprise. The internal structure of the German armaments industry, however, did not allow the output of different units in short intervals, as satisfactory results depended on the construction of a great number of one and the same unit. Thus, a greater variety of already developed small fighting units could not be produced.

Success or failure in operating these units solely depends on the spirit and personality of the "single-fighter" who left alone at sea and without tactical guid-

ance is compelled to determine himself the decisive moment for his attack.

The first small fighting units were:

The One-Man Torpedo.

The Explosive Boat.

Soon afterwards, two types of one-man submarines were developed. During the landing operations at Nettuno the One-Man Torpedoes were engaged for the first time which brought most valuable experience as to transportation, launching, navigation and tactical possibilities for later operations. On account of technical difficulties and unfavorable coastal conditions, only 15 of the launched 28 units reached the operation area. Three units were lost.

These engagements showed clearly the limits for operating these units which were determined by the low speed, the wide turning circle and the low eye level.

At the beginning of the invasion in Northern France the units under construction were not as yet completed, thus preventing the concentrated attack of numerous and various units in the most favorable period for their defense operations.

The first squadrons of One-Man Torpedoes and Explosive Boats began to operate in the Seine-Bay in the beginning of August, 1944. The squadron consisted of 60 units. Every unit was transported on a special trailer movable by tractor or truck. Transportation was effected by rail up to a station on the outskirts of the front line from where they proceeded by road to their final destinations. A special trained pioneer group was attached to every squadron. Launching of the units was effected without difficulties near the main frontline by making use of groynes or other existing facilities.

Prevailing current conditions and distances to anchorages of enemy's transporters admitted the operation of One-Man Torpedoes on specific dates only when the outward journey could be effected at low tide, the attack carried out at stillwater and return be accomplished at high tide. Times had to be calculated with a view to launch the units possibly after dawn. The units were launched in intervals of 1 to 1½ minutes from each other. Besides these tidal conditions, operations depended upon the motion of the sea (limit as at 2–3) and light conditions.

At the first operations the only navigatory instrument was a moon-compass. Further navigatory assistance was rendered by a directive-searchlight erected on the main frontline, the light house of Le Havre (lightened with prewar intensity) and by provocation of flak (antiaircraft) fire through coincided air attacks.

The success obtained by the One-Man Torpedoes surmounted the expectations by far, whereas the difficulties experienced and losses involved were below the standard. Three squadrons in total were engaged in the operations; losses amounted to 20 percent in personnel, whereas all units were blown up after landing. Losses happened generally on the return march at daylight, while the single-fighter was exposed to any attack without the least protection. For this reason the next boats were made able to dive, but did not enter into action any more.

The first Explosive Boats were completed by beginning of August 1944. They started to operate by the end of the month. Squadrons were formed and transportation effected similar to the system adopted for the One-Man Torpedoes. This attempt had to be withdrawn owing to unfavorable weather conditions. This trial, however, gave the most valuable experiences as to technical, navigatory and tactical possibilities of these boats, which were operated (twice) later on the Seine-Bay where they were launched in the outer-se-

The German *Molch*, one of the midget U-boats used against the Allies' shipping in the European theatre, is shown above. Requiring a crew of only one man, the midget is 35 feet long, displaces between 10 and 12 tons, and has two speeds—two knots and three knots. The boat can operate for 36 hours regardless of speed.

curity-zone. The greater number of the Boats launched succeeded in approaching the landing vessels without being discovered. As long as the boats lied afloat with their engines stopped they were not noticed by the escorting vessels even within shortest distance. After switching on the wireless-control-lamps, however, heavy defense fire started with the result of the destruction of several Explosive Boats but without personnel casualties, owing to the fact that at this state the boats were already steered by wireless and therefore left by the crews.

The combat units of these Explosive Boats were composed as follows: 1 Pilot Boat and 2 Explosive Boats.

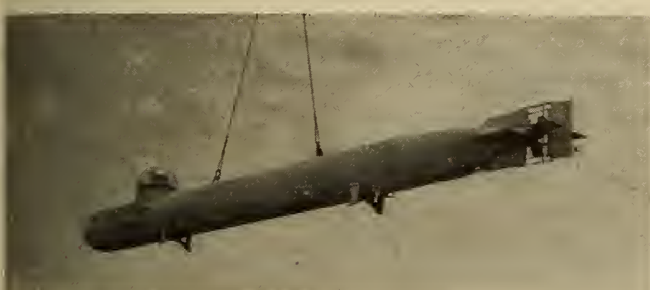
The Explosive Boats were manned with one driver each. The complete combat unit was conducted in close formation until the operation zone was reached; then the explosive-charge was duly prepared for immediate ignition and the wireless control switched on. The drivers of the Explosive Boats jumped overboard and were rescued either before or after the attack by the pilot boat. This rescue work was nearly always carried out with success.

During the extension of the enemy's operation in the Normandy one squadron of One-Man Torpedoes was enroute to the front but had to be diverted to Italy owing to the loss of base-ports in the Seine-Bay.

With regard to the One-Man Submarines, there were 12 "Bibers" only operating in the Seine-Bay.

The second type of One-Man Submarines, the "Molch," was developed at the same time but not completed in time for operations in this combat zone.

At about the same time when the operating bases for small fighting units in the Seine-Bay were lost, the pre-planned delivery of large amount of fighting units began. The prepared squadrons, of One-Man Torpedoes, One-Man Submarines and Explosive Boats were included in the coastal defense in autumn, 1944, when the coasts of Jutland and Norway were reconsidered under special menace. Further squadrons were located on Friesen Islands.



The *Marder* type of German midget U-boat has a speed of between 3 and 3½ knots with torpedo and approximately 2 knots submerged. Typical of the German midgets, the Marder has a one-man crew and has an estimated endurance, at 3 knots, of between 20 and 24 hours.

During the landing operations on the South-French coast no fighting units were in Italy which could have been used, except a small amount of Italian SMA-Boats. The existing Storm-Boats were started in nine succeeding nights. They, thereafter, had to stop their operations on account of the loss of satisfactory starting bases, and the always increasing way of approach for the operations on the South-French coast. Several "Marder" squadrons were transferred from France as well as the first available "Molch" squadron. On account of the prevailing difficulties of transportation, the squadrons did not arrive on time, and, therefore, could only be put into operation against enemy coastal defense forces.

As no other naval forces were available in that area, small fighting units had also to be used for offensive attacks with a view to disturb bombardments of cruisers and destroyers which caused heavy losses on shore. A direct success was not expected by these operations. For the first time, several units of the "Molch" squadron were started in these offensive operations. Experiences were bad; losss at the first trial heavy. The Italian Storm Boats proved to be unsuitable for the required operations as the top speed decreased rapidly already after a few operations and the drivers were not able to overcome the tactical difficulties in operations against moving targets.

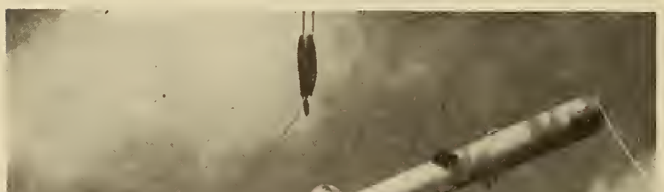
The port of Antwerp being re-opened a trial had to be started to put small fighting units in offensive action against the Thames-Schelde traffic. At first, operations with small fighting units in this area seemed to be impossible. Main reasons were difficulties in navigation, insufficient range of the existing fighting units and lack of trained personnel. The respective fighting units, the Two-Man Submarines and small speedboats which had been developed to meet this situation were not yet ready for action.

Due to the decisive importance of Antwerp as a supply base, an attempt had to be made to succeed with the existing fighting units. Therefore units were transferred from their bases in Denmark and the German Bay to Holland. As long as the Zeeland Islands and the inland waterways of the Maas-mouth could be used, all possibilities were fully exhausted by pursuing the operations for Explosive Boats comparatively easy with the assistance of a pilot. After the loss of the Isle of Walcheren and the coast line on the main land new ways were to be found in order to compensate. The small operating range of "Molch" and "Biber" was overcome by towing the units by boats of the Rhine-flotilla so far that the crews could reach the operating area. Thus, they could return after two hours' operation to the area which was held by German forces. For the march to and from the operating bases, tides had to be taken into consideration for the operating plans. Thus, only on a few days of a month favorable conditions prevailed. The season was extremely unfavorable for these units as there existed either calm weather with fog or very bad visibility or rough sea which prevented operations. To increase the operation range of Explosive Boats, a construction was developed which permitted the transportation of these boats on normal Motor-Torpedo-Boats. Such an operation was carried out once only. The "Molch" was put into trial operation only twice. The difference of water density in the mouths of Schelde and Maas caused so many difficulties to the drivers in maneuvering their boats that operations had to be stopped. The trial trips with the "Biber" constructed as a surface boat were far better.

At the end of December the "Seehund" came into action as the first small fighting unit specially constructed for offensive operations. This small submarine was a further development of the "Hecht," a submarine originally designed for mine tasks in combined operations. Its fighting power and range, however, were

in no comparison with construction cost. The "Seehund" which was constructed to comply with all technical requirements of a submarine met with all expectations. Due to its weight and the required basis organization, operations could only start from a prepared base. Only a few days were needed for preparing Ijmuiden for this purpose. The first operation of this new weapon was at the same time the most difficult one. Reasons were unexpectedly bad weather and certain constructive deficiencies. Heavy losses were the result. Of 18 boats which had started, only 11 returned. The experiences of these operations could promptly be made use of with the result that from the second operation onward losses became very small. About 10 percent of the boats were lost with their crews. The "Seehund" seemed to become a very efficient weapon on the long run. To a large extent the boats were unsensible against waterbombs and wireless spotting. Even boats which were chased hard, in general, showed no defects which made them unfit for maneuvers. About 70 percent of all boats had enemy contact. In many cases, however, the drivers missed the targets due to lack of experience. At the middle of April all conditions were such that "Seehund" operations could become effective. A sufficient amount of units and experienced crews as well as sufficient alternative bases existed to guarantee undisturbed operation.

The Smoll-Motor-Torpedo-Boat constructed for the same purpose could not be put into action any more, as the first squadron was ready for action by the beginning of May only. Operations with Explosive Boats, "Biber" and "Molch" were stopped when a contact with the enemy during night hours became more and more unprobable on account of the following reasons: The steadily increasing enemy defense, the systematic demarcation of all areas reached by the small fighting units and the stopping of convoy traffic on the Thames-Schelde track at night at the Schelde-mouth. Only Explosive Boats continued operations in the old area



The German *Hai* midget U-boat was not developed soon enough to be used before the war ended.

to make commando raids in the Zeeland waters in order to disturb continuously the enemy. Solely, the "Seehund" continued offensive operations. Squadrons of "Biber," "Molch" and Explosive Boats no more needed in Holland were made a part of the coastal defense of Norway and Denmark in conjunction with the "Marder" squadrons now fit to dive.

The units were so located that the fighting strength on the West and South Norwegian coast increased, whereas a decrease on the Westfjord took place. Besides the technical weapons, specialists were trained for commando raids.

"Marine Commandos" and "Commando Swimmers" were created which came into action in the course of commando-raids. In the beginning, these units investigated systematically the enemy front to gather the necessary details for operations. With the beginning of the invasion in the Normandy, these units were increasingly used for offensive purposes, i.e., destruction of abandoned artillery stands, destruction of port installations already occupied by the enemy, of docks and river passages. Based on the experiences in the West, similar raids were made on a larger scale in the Adria and Dalmatian Island area. For the purpose of increasing the range of the operating area Motor-Torpedo-Boats were used for transportation. In the operating area itself, Storm Boats and finally Kajaks were used. The intended extension of operation could not turn effective anymore due to the increasing shortage of fuels.

In the Norwegian coastal waters, the "Marine Commandos" made only preparatory investigations. Due to the loss of the naval bases, the units of this command were preferably used for operations on rivers and inland waters to perform the destruction of bridge heads as well as bridges in territories occupied by the enemy. All preparations made for the destruction of the bridges in the Baranow bridge-head had to be stopped due to the suddenly beginning ice movement. Operations on the lower Danube and the Balaton Lake were successful only in part. The attempt to destroy the road bridge of Mijmwegen in addition to the railroad bridge was seven times repeated with different compositions of fighting units and without success. On the lower Rhine they were prevented from action. In the bridge-head at Remagen they were too late for action, the enemy's advance being too quick. In the East the fighting units operated on the Oder between Kustria and the mouth of the river. Due to the loss of the Rhine and the Oder positions, the units were divided into recognition commands for the purpose of continuously maintaining contact with the advance troops of the enemy. Communication was built up through couriers and wireless.

The top organization of all units under this command was the staff under the direction of Vice Ad-

SUICIDE BOATS AND TORPEDOES

miral Heye as Commander-in-Chief. He, at the same time, formed an independent department in the Supreme Command of the German Navy. This was established with a view to avoid the often long way of bureaucratic instances. The staff had to elaborate operative plans and fulfill the duties of administration as well as the development of new fighting units. In addition, contact to the armaments industry had to be maintained. A special scientific department based upon large records had to furnish the details for operative plans.

Owing to the special character and variety of the fighting units, it was necessary to appoint special operating staffs which were independent from local naval high commands. After a period of improvisation at the beginning, the squadrons and fighting groups were duly organized by the formation of K-divisions in accordance with the special requirements of every operation area. This direct management and specialized organization enabled the command to maintain its proper character up to the last days of war. At the end of the war, the command of the small fighting units had just reached the point to its own development.

Experience taught that for naval operations near the coast small fighting units are more efficient than the previously employed naval units. The risk of human lives is by far inferior compared with the success. New plans materialized from experiences which would have rendered still more effective results of the small fighting units. The end of the war prevented the appearance of these new units.

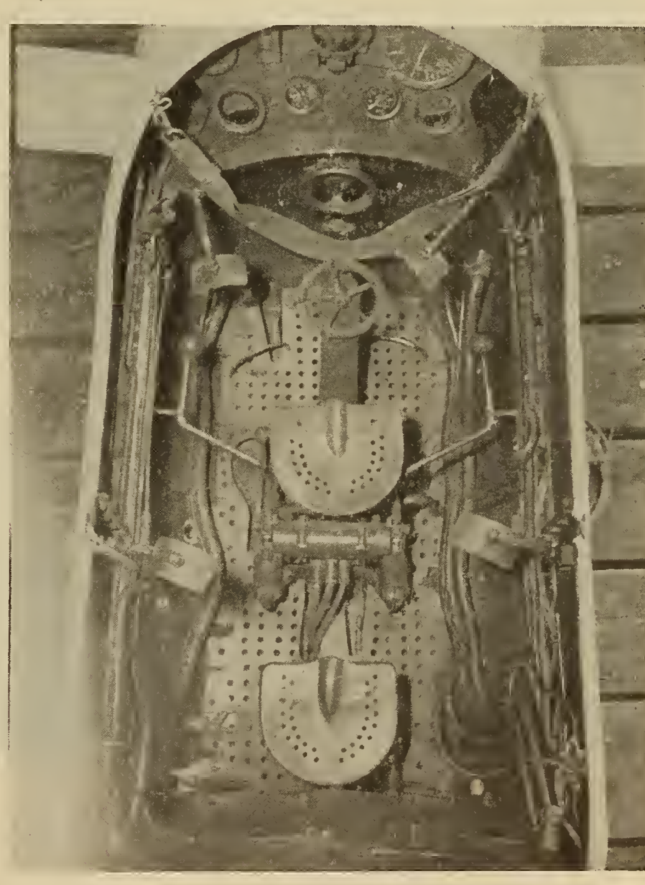
The first organized units of small boats designed to set off depth charges alongside Allied ships were encountered during the amphibious landing in Lingayen Gulf in January, 1945. Before that, improvised craft ranging from mine-carrying wooden rafts to converted torpedo boats had attempted suicide attacks against shipping, but these were unorganized, isolated attempts. The small boat units were not, in the same sense as the Kamikaze plane units, suicide attackers. With the boats, the possibilities of escape, both of the boat and of the crew, were greater. The odds against escape were so great, however, that the same spirit of self-sacrifice was required for the successful use of the boats as was required by the crash-dive pilots. For this reason, the boats were considered one more unit in the array of Japanese suicide weapons.

TYPES OF BOATS

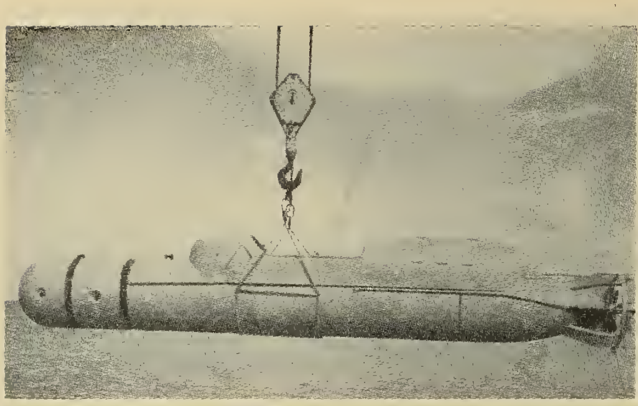
Three types of suicide boats have been found to date. Each has varied slightly from the others in size and armament. Craft of the "Special Boat Unit" of the Army Shipping Engineers were seized at Lingayen shortly after the initial landing on 9 January. These were one-man boats made of plywood, 18 feet, 6 inches long with a beam of 5 feet, 10 inches. Power was supplied by a Chevrolet type engine with an estimated speed of 35 knots. This type carried two 120 kg. depth charges which could be dropped by the operator close aboard the target ships or released automatically if the attacking boats crashed into the targets. This type of boat also had a steering gear which could be locked in position, allowing the operator to aim at the target and go over the side.

At Kerama Retto 300 suicide boats, shorter and wider than those on Luzon, were discovered. These boats, Navy-manned, were 18 feet long, with a beam of 6 feet. Their armament differed from the Army boats described above in that the depth charges were carried in racks on the stern instead of on both sides. These boats, too, were operated by one man. Their speed ranged from 6½ to 35 knots. The depth charges could be released either by the operator or upon impact with the target.

A third type of boat was encountered at Okinawa. It was smaller than either of the other two and, instead of depth charges, carried two rockets and a 559-pound explosive charge in the bow. The rockets, placed on



An interior view of the Italian *SSB*.



The Italian midget submarine SSB has four speeds, 4 and 4½ in fast speed, and ½ and 1½ in slow. This craft, approximately *22* feet in length, does not carry torpedoes but has two war heads or explosive charges. The tactical operation is to attach charges to the keel of a ship, the job being performed by two men with special diving suits and diving masks.

both sides of the cockpit, weighed 49½ pounds each.

SUICIDE BOAT TACTICS

Captured documents outlining tactics for suicide boats stress the value of surprise, of attacks from several directions at once, and of dropping depth charges close to the target. The most vulnerable parts of the ship are considered to be the areas immediately below the stacks and abeam of the holds. If these points cannot be hit, small boat operators are advised to immobilize the ship by attacking propeller and rudders.

Small boat attackers make use of land masses and darkness to conceal their approach. Some also have shown expert awareness of blind spots in ships' guards when making approaches. On one occasion, a single boat approached from the darkest spot on the horizon and roared in on a United States net tender from dead ahead. Because of the predetermined angle of attack, the position of the foremast and horns on this type of ship prevented the training of guns on the boat. The boat fired six rounds from a small caliber machine gun while coming in. Then, swinging across the tender's bow too close for its guns to bear, the attacking craft raced to within 40 to 60 feet broad on the port bow, dropped a depth charge over its own port side and turned sharply to starboard.

SUICIDE BOAT COUNTER-MEASURES

Small boat attacks can be expected wherever there is enemy-held territory nearby which can shelter and hide the craft. Groups of islands are likely operating areas.

Explosive motor boats are small, of high speed, which carry heavy explosive charges and attempt to ram their target so that a "trigger rail" on the bow sets off the heavy charge in the boat. The operator abandons his boat a reasonable distance from the target after setting it on a collision course. The Italian MTM explosive motor boat, shown above, is capable of a speed up to 30 knots. At slow speeds, the boat operates fairly silently, requiring the best listening devices to detect it. This boat was used quite extensively by the Italians.

Many attacks have occurred at night, especially between the hours of 2400 and 0400. Experience has demonstrated the wisdom of having visual lookouts, searchlights, and machine gun batteries fully manned during these hours. In addition, limitations of train and depression of armament on most vessels have made it necessary to have patrols equipped with small arms for firing on approaching small craft or objects of a suspicious nature. Suicide boats, because of their light construction, are extremely vulnerable to fire from guns of almost any caliber. In preparing such defenses, however, it has been necessary to caution personnel against illuminating and shooting into friendly ships' boats.

Battle experience has shown that suicide boats rarely are detected by radar, as a result of their low freeboard and small size. There have been instances of a few being picked up by sound gear. The combination of a small blip on the radar and high speed screws on the sound gear may, together, foretell the approach of this craft.

THE PILOTED TORPEDO

A variation of the small boat attack of a more definitely suicide character is the piloted torpedo. The only known instance of an attack by this weapon occurred at Ulithi. A partial torpedo was recovered there near the point of an explosion heard on 20 November 1944. The same day a Fleet tanker was torpedoed in the anchorage and "midget submarines" were reported in the area. On 12 January 1945, an AE was attacked at Ulithi and metal fragments recovered from the deck have now been identified as part of the conning tower of a piloted torpedo.

It is thought that this weapon usually is carried on the deck of a "mother" submarine. Before entering combat waters, the operator is placed in the torpedo. He is supplied air by the parent sub as the submerged approach is made. When the target is within range, the piloted torpedo is detached and the operator drives directly to the target.

The calculated range for the ordinary 8th year type torpedo is approximately 21,000 yards at 26 knots. At the same speed, the increased weight and size of the human-piloted model probably would reduce this range. However, at a much slower speed, it should be possible for the parent sub to launch its "human torpedo" at distances up to 15 miles from the target. Unlike the Italian human torpedo, the Japanese version of this weapon of desperation has no provision for the escape of its pilot immediately prior to impact.

SUICIDE SWIMMERS

In some cases, lone swimmers have attacked ships and

This Navy-type Japanese explosive boat with rockets fitted its side. This type of boat was captured at Okinawa, the first discovery of the rocket-carrying weapon. Lanyard fired from launchers on each side of the cockpit, each rocket contains a ¾-pound charge of explosive which is set off at ranges up to 2,000 yards, scattering incendiary pellets. The purpose of the rockets is apparently to disrupt gun crews and small-arms fire from the intended target during the run-in.

landing craft, armed with hand grenades or other small explosive charges.

A prisoner of war captured at Peleliu stated that he was attached to a special unit (Kaiyutai) composed of one warrant officer, one noncommissioned officer, and 20 enlisted men whose mission it was to attack enemy barges in the water and blow them up. Each man was armed with three hand grenades, a knife, a rifle and demolition charges. The demolition charges consisted of wooden boxes, 4 inches wide, 8 inches long, and 5 inches high, filled with a yellow powder (probably picric acid). The fuze was adjustable.

The prisoner stated that this unit at Peleliu was merely a local tactical expediency and that, as far as he knew, no similar units had been formed elsewhere. Other instances of suicide swimmers have, however, appeared in various operations, indicating the use of such tactics elsewhere by the Japanese armed forces.

The USS LSM 277 reported killing a Japanese swimmer whose body was later found on a reef, together with several grenades. At Lingayen Gulf, several swimmers killed by gun crews were reported to have had explosives strapped on their backs. A single picket boat reported killing several Japanese swimming under boxes. Most of them were officers. They were said to be carrying grenades and other small explosives.

The best countermeasure against such swimming attacks is an alert armed watch while at anchor near enemy-held territory.

SNEAK CRAFT—THE EFFECT ON THE HARBOR DEFENSE TRAINING PROGRAM

From the time of Pearl Harbor, it was known that harbor defense personnel would have to be on the alert for possible sneak craft attack. In the Mediterranean, the Italian had utilized sneak craft and this information was known to us. It was therefore pointed out to all harbor defense trainees that sneak craft were an ever-present danger, and that increased vigilance would be necessary in order to detect the presence of such craft.

However, during this time there was no concrete example to teach a new student of what a midget submarine sounded like, or what a magnetic Loop signature might look like. Thus the training program as far as sneak craft were concerned necessarily amounted to making constant references to the danger of sneak craft attack, and emphasizing data contained in harbor defense bulletins and magazines.

The British midget submarine, called the "Chariot", is essentially of the same design as the Italian SSB, not intended for torpedo action but designed for special swimmers.

It was not until the fall of 1944 that we were able to get some concrete information on sneak craft, information concerning what type of sound was produced by one and what magnetic and acoustic characteristics were. This came about when the Chief of Naval Operations arranged for a British Sleeping Beauty to be taken to Naval Training School (Harbor Defense), Fishers Island, New York, for some exhaustive tests. This was a very excellent British craft, manned by capable British personnel. It was a one-man submarine, about 20 feet long, propelled by a single electric motor. Previous tests made on British sound equipment indicated detection possibilities to be very difficult.

The craft was operated under various conditions for a period of about 10 days. Runs were made both surfaced and submerged over single and Multi-Turn Magnetic Loops, UEP systems, and near Radio-Sono-Buoys, Cable-Connected Hydrophones, and Herald equipment. Sound recordings were made of all sounds.

Upon the conclusion of these tests, it was definitely shown that the sneak craft attack was much more of a problem than had been previously thought. The Sleeping Beauty made runs over Magnetic Loops and UEP without causing any signatures because of being made of non-magnetic material. Runs near Herald equipment revealed that it was impossible to "ping" on this type of craft with the normal Herald gear, though it was possible to faintly hear the craft's propellers at a short range. Sonic listening on both Sono-Buoys and Hydrophones proved to be equally difficult, and it was felt that only the most experienced operator with most acute ears might hear the craft at all.

Armed with this data, the training program at NTS, Fishers Island, had something concrete to give to student operators. The sound recordings were used for training purposes to point out what such a craft might sound like, and how alert an operator must be to pick it up. Likewise, cognizant Bureaus in Washington took steps to see what could be done with existing equipment to improve the possibility of detecting a sneak craft attack.

Two important steps were taken by the further development of the Multi-Turn Loop with discriminator unit, and the new idea of the Short Pulse Herald. The M. T. Loop was a development already in process, but immediately more stress was placed on the training program so that operators were familiar with the workings of the discriminator unit and the resultant additional interpretations of signatures, disturbances, etc.

The Short Pulse Herald appeared to be one of the most promising developments. Initial experiments were conducted under the supervision of Naval Research Laboratory. Tests were undertaken with a QBH Herald, modified for short pulse operation. The tests were conducted by using 28″ and 32″ mine cases as targets. These cases were weighted and then tied to a float and allowed to drift past the Herald unit, the mine case being submerged at various depths up to 20 feet. Results of this experiment were very encouraging. The mine cases could be "pinged" on up to ranges of 600 yards in some cases. A modified Sangamo chemical recorder was used, since at the very short keying interval used the operator could not hear the echo at times, and since Doppler effect could not be determined. The problem resolved itself into a matter of the operator being experienced in interpreting the traces on the recorder.

It was evident that Short Pulse Heralds were one answer to the sneak craft problem. Placed so as to "ping" across a channel, it was believed that up to 600 yards there was a good chance of detection.

An immediate change, or addition, in the training

program was made. Personnel were taught interpretation of recorder traces, operation of the Sangamo Recorder, and the other various intricacies of operating a short pulse Herald.

In the spring of 1945, an Italian Explosive Motor Boat was taken to Fishers Island, where the same type of tests were made as had been previously made on the Sleeping Beauty. The nature of the tests was the same, and the results also similar, though this boat was not a submersible and the problem was somewhat different. Sonic listening proved much better for this type of craft than any of the other harbor defense equipment. Sound recordings were made, and the training program promptly enlarged to include training of operators in what to expect from this type of craft.

From the information and data obtained on sneak craft as the result of this preliminary insight into the operation of sneak craft, the Chief of Naval Operations embarked on a test program to determine exactly what could be done to detect all known sneak craft—and to make tests to see what new developments and improvements could be made to make detection more positive. The Experimental Harbor Underwater Detection Station at Ft. Lauderdale, Florida, was installed in July, 1945, and experimental tests were begun 1 August 1945 on 11 different types of sneak craft.

Section IX—PASSIVE DEFENSE

GENERAL

Passive Defense embraces all measures necessary to minimize the effect of damage resulting from enemy action.

In the following subsections important elements of passive defense are listed with general comments. No attempt is made to present technical data and details, since such information is furnished in Navy Department publications. (Selected list of references appended).

It is considered that passive defense measures should support and augment the Active Defense. As a matter of general policy it may be stated that where a passive defense plan prevents the effective use of a weapon or otherwise conflicts with the Active Defense, the passive defense plan should be modified, but where an effective passive defense measure interferes with administrative procedure, the administrative procedure should be changed.

DISPERSION

The principles of dispersion should be given full consideration in planning the location of base buildings, facilities, equipment, stores and personnel shelters. Under a bombing attack, a base having all facilities concentrated in one or two small areas is more likely to suffer severe damage than is a base where facilities have been dispersed in accordance with a practical plan.

In addition to spacing between locations, the dispersion plan must also take into consideration the overall plot plan of the base. Location of buildings along a straight line should be avoided as this layout presents several targets on one bomb run. This principle applies equally well in temporary placement of equipment and vehicles including aircraft.

The camouflage plan and the plan for the control of incendiaries are usually in harmony with the principles of dispersion—the former because a straight line layout is difficult to conceal and thus is to be avoided where practicable, and the latter because effective control requires tha there be no large concentrations of combustible material.

CAMOUFLAGE

Camouflage includes any means used to hide or disguise a position from the enemy, to confuse him in his attack so that either he wastes his striking power or through delay in recognizing the position, he presents a better target to the defending forces.

It is the endeavor of camouflage that the installation as viewed from the air presents no conspicuous features which are in contrast to the adjacent area. Where practicable, the utmost use should be made of natural growth through proper consideration in planning the location of buildings and installations. In construction or preparing sites the less natural growth that is destroyed, the easier is the task of camouflage. It is considered that the efficient plan will make every use of the material found at the location by transplanting, seeding and transporting sand, soil, and other material as necessary to reduce the conspicuousness of the station.

In addition to the foregoing landscaping measures, it is considered that the station camouflage plan will include details of such artificial measures as might be erected when warranted by the menace of enemy attack, to disguise or conceal the most vital installations at the station. Also where appropriate decoy airplanes and guns may be constructed of scrap material on hand. Details of construction are contained in the referenced BuDocks pamphlet.

ILLUMINATION CONTROL

Lighting should be arranged and held to a minimum consistent with night operations required and should conform to prescribed standards with respect to shielding, intensity, and means for prompt extinguishment.

Lighting on and about ships at piers generally is subject to the same restrictions as outside lighting on shore, except that consideration must be given to the control of water reflection.

Aerial observation is, of course, the final test of the effectiveness of the illumination control plan regardless of its conformity to prescribed intensity standards. Frequent flights will be necessary to observe the overall intensity pattern of outside lighting and the effectiveness of blackout drills.

PROTECTION FROM BOMB SPLINTERS

No new building under Navy cognizance should be designed without thought for protection from air attacks. While this principle applies to all phases of passive defense, it is particularly applicable to protection from bomb splinters and blast. Measures for the protection of personnel and equipment with respect to both building construction and the location of the building site should be considered. Consideration should also be given in all cases of new construction to the provision of those basic structural arrangements and layouts which will later allow complete protective con-

struction features to be added progressively should the need arise.

Where time and material requirements do not allow the construction of "permanent" shelters, damage from direct bomb hits can be localized and protection from near misses can be provided by sandbags, concrete blocks, claybricks, rammed earth walls, earth filled bulkheads, and through the use of soil stabilized with emulsified asphalt or Portland cement. For construction details on recommended thicknesses of the various types of barrier walls attention is invited to specifications in the referenced handbook.

Where deemed advisable individual protection can be provided by widely dispersed slit trenches, with braced side walls, each having a capacity of one or two men and situated so that they can be quickly reached.

INCENDIARY CONTROL

In planning the defense against incendiary bombs the premise should be taken that in an attack it is likely hundreds of incendiaries will be dropped in an interval of a few minutes time and that prompt extinguishment of the resulting scattered fires cannot be accomplished by the regular fire fighting forces of the base. The incendiary control plan should divide the base into small areas, and a squad trained in incendiary extinguishment should be assigned to be responsible for each area. Each squad should have the necessary extinguishing equipment and adequate water supplies immediately available. The regular fire fighting force will be directed to go to the aid of area squads as necessary, priority being given to important locations.

In order that squads may effectively deal with incendiaries all areas where bombs may have to be combatted should be made readily accessible. Roofs and attics should be provided with two or more means of access, and stores should be arranged with passageways and cross aisles wide enough to permit passage of portable fire fighting equipment. Where practicable large accumulations of stores or combustible material should be avoided by dispersing to separated locations.

It should be noted that a percentage of the incendiaries may be of an anti-personnel type containing an explosive charge.

CHEMICAL WARFARE DEFENSE

The formulating of Chemical Warfare Defense plans requires a knowledge of the characteristics of the various gases, of the methods by which they may be applied and of the various means of individual and collective protection and decontamination. Preparation and adoption of these plans can best be accomplished under the direction of an officer who has received special training and is qualified for this work.

Gas masks and protective clothing are the basic protection items, and personnel should be trained until their use becomes automatic. Such training will minimize fear and panic which are usually the reactions of the untrained.

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FIRE PREVENTION AND PROTECTION

Most fires can be prevented by means of competent supervision and frequent thorough inspections to insure that causative hazards are properly safeguarded.

Such fires as do occur may usually be extinguished in the incipient stage with little or no resulting damage, provided that, in addition to the above-mentioned supervision and inspections, an adequate number of suitable type first-aid fire-extinguishing appliances have been installed, personnel have been instructed in their use, and alarm equipment or alternate arrangements have been provided to summon aid.

In the event that a fire passes the incipient stage, a control usually requires a trained fire-fighting organization, a reliable water supply of large volume, fire hose,

and mobile pumping equipment, if the water supply is not available under pressure at well-spaced fire hydrants. Even though such a fire is eventually brought under control by hose streams, the loss will probably be heavy and may approach total proportions unless values have been judiciously sub-divided by means of physical barriers to the spread of fire. Such barriers usually consist of parapeted and fendered masonry walls with openings, if any, protected by automatic fire doors, or a clear space between buildings of fifty feet or more.

Fire protection in all of its phases is a highly specialized field of engineering but effective loss prevention work can be accomplished by inexperienced personnel if suitably indoctrinated in a few fundamental principles embracing causative and contributory hazards.

The most common causative hazards include heating devices and other flame-producing or flame-utilizing appliances. Such devices should be located as far from combustible stock and fixtures as practicable and where it is not feasible to provide ample clear space between the device (including vents and stacks) and combustible parts of the building, separation should be accomplished by means of insulated and ventilated incombustible shields. If it is considered that a hazard still prevails, the device should be under the observation of an attendant whenever it is in operation. Appliances employing open flames must not be installed in rooms where inflammable vapors may be present. Devices should be frequently inspected and promptly repaired if there are any defects through which a fire might be caused by escape of flames or sparks, or by a heated surface coming in contact with combustibles. In connection with the hazard of sparks and smoldering embers, smoking ordinarily should be prohibited in buldings having other than incombustible floors and contents.

Many fires are attributed to electrical defects and, because of the technical problems involved, the safety of such equipment should be made a responsibility of the electrical maintenance force of the base.

Good housekeeping must be maintained, not only because certain discarded materials are subject to spontaneous ignition, but also because accumulations of rubbish and congesed storage withou adequate aisleways are a most important contributory hazard. In connection with contributory hazards, materials subject to spontaneous heating and flammable liquids should be stored in a small well detached building used for no other purpose.

First-aid fire-extinguishing appliances usually consist of hand extinguishers of various types ordinarily containing (A) water for fires in ordinary combustible materials, (B) foam-producing ingredients or carbon tetrachloride for fires in oils and greases, and (C) carbon tetrachloride or carbon dioxide for electrical fires. Water casks and pails may be provided as a substitute for Class (A) extinguishers, and sand bins and shovels or pails for Class (B). For fires in electrical equipment, water may often be used AFTER THE SWITCHES HAVE BEEN OPENED.

Properly designed and installed automatic sprinkler equipment, having an adequate and reliable water supply, is universally recognized as the best means of controlling fires but it should be emphasized that the installation of automatic sprinklers does not lessen the need for protective measures.

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INTERNAL SECURITY

GENERAL

Internal security embraces the safeguarding of the Naval Shore Activity from sabotage, espionage, fire, robbery and involves plant protection, traffic control, care in selection of employees, alarm systems, and security of the essential service (water, electricity, etc.). In brief internal security is the safeguarding of the naval activity from any incident, except open attack, which might disrupt its normal efficacy.

Internal security can be divided broadly into two categories, personnel security and physical security. In activities having industrial departments personnel security measures are of prime importance.

GUARD FORCE

The primary task of the guard force is to prevent unauthorized entry. Fences, gate locks, floodlighting, mechanical alarm systems and raised boundary posts are all aids to the guard force and enable a more efficient use of guards in accomplishing this task.

The number of guards needed by a particular base

can only be determined by inspection and consideration of the following factors: size and importance of the base, areas requiring protection, topography of surrounding territory, waterfront areas, number of visitors, number of base personnel, whether located in an isolated section or adjacent to an urban area, and fences, floodlighting and other aids which have been provided. At activities covering large open areas, mounted guards have proven to be effective as have trained sentry dogs where used as an auxiliary to the guard force.

PROTECTION OF UTILITIES

Since uninterrupted supplies of water, electricity, and in some instances other services are usually necessary to maintain operations, consideration must be given to practical measures for their protection by the provision of guards, fencing or other measures. Where the base is dependent on a single source of supply, and especially where this supply is not of the highest reliability, it may be desirable to furnish an auxiliary standby source capable of sustaining limited operations during the period of interruption of the main supply.

PURITY OF FOOD AND WATER

The incapacitating of base personnel by contamination of water or food supplies through the introduction of disease germs or poisons is a possibility which must be considered. Precautions to be taken include regular analysis of water samples and thorough inspection of all food supplies in every stage from its procurement to consumption.

SECURITY OF CLASSIFIED MATTER

Navy Regulations and the Registered Publication Manual set forth instructions for the handling of safeguarding of restricted, confidential and secret documents including stowage to be provided, shipping and mailing procedure, disposition in the event of capture or destruction of a base, and report to be made if compromise is suspected. It is obligatory that all personnel handling classified matter understand and observe these instructions.

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HERCULOX BINDER

INSTRUCTIONS FOR OPERATING

Aligner

Sheet P
Sheet Pc
Lock Po
Lock Cy
Lock Rin

TO OPEN

TWIST RING SLIGHTLY AND PULL UP.

TO CLOSE

REPLACE LOCKING CYLINDER ON LOCKING POST.

REMOVING AND INSERTING SHEETS

LIFT SHEETS ABOVE PLACE OF INSERTION OR REMOVAL, AS ILLUSTRATED

EAF CORP.
Y.
23